TOM PETERS ON THE TEN DEADLY SINS

highTechnology

MAY 1986
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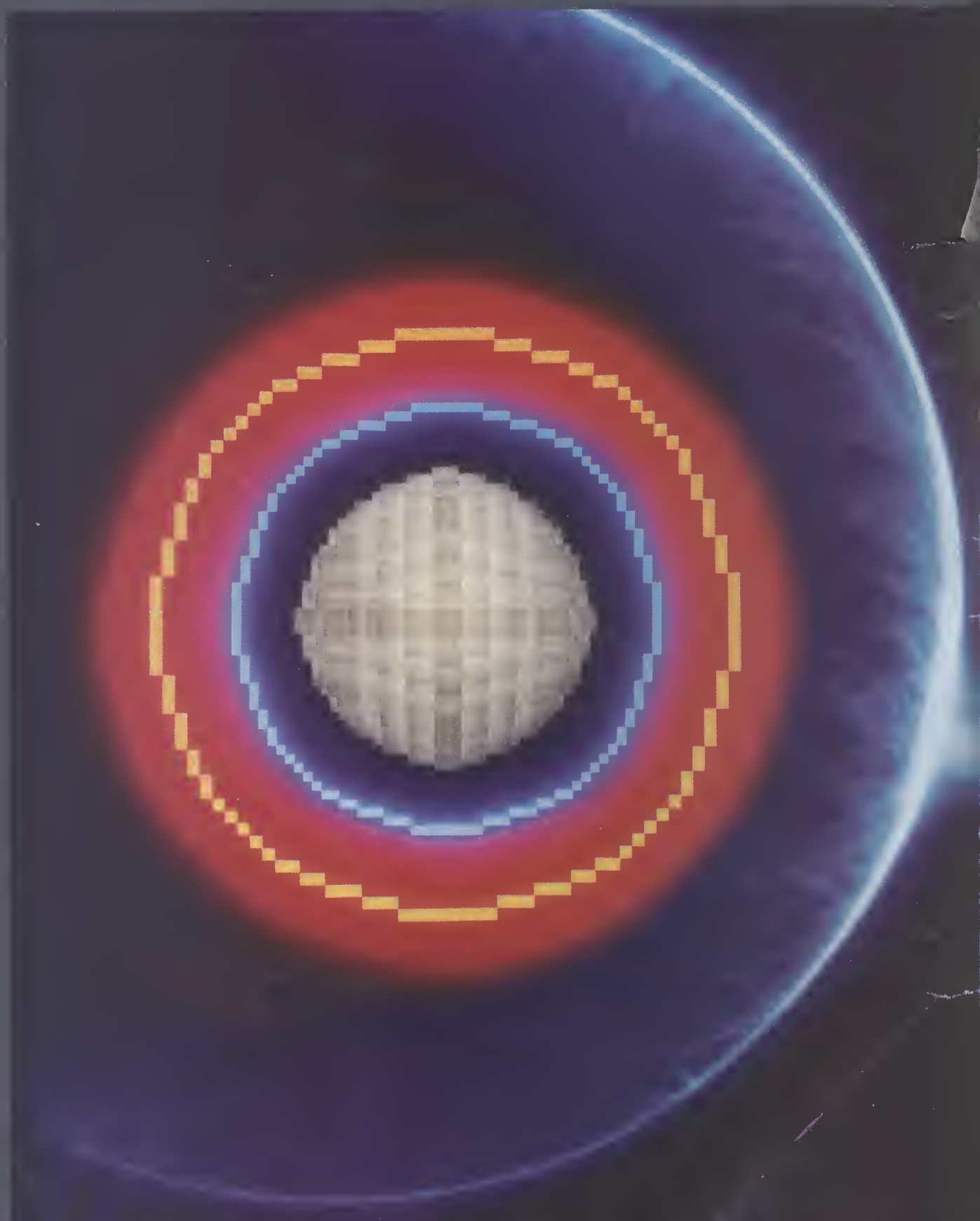

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FEATURES

TELECOMMUNICATIONS

DEPARTMENTS

Is the military buildup distorting our national priorities?

We visit high technology plants all the time, but two recent visits on successive days provided a counterpoint that starkly portrayed our national priorities. Both facilities were divisions of large, diversified U.S. corporations. One factory makes advanced robotics for industry, while the other produces an array of missiles and other weapon systems. There were competent, dedicated, technically knowledgeable personnel at each company. And at both of them we saw innovative products, the fruits of creative research by American laboratories.

But that's where the similarities ended. At the robot factory one felt far from the action. It was small, in an unpretentious urban setting, and, aside from one delivery van, the visitors parking area was empty. The scope of operations had been drastically narrowed recently due to tough market conditions. Instead of an aggressive push toward a broad range of robot applications, the plant now plans to concentrate on a narrow niche market. The marketing goal is being limited to replacing less capable robots already in use. And even there the strategy is based on adding some innovative technology to a Japanese robot. The company's austerity program precludes efforts to pioneer new robot markets.

What a contrast at the military contractor! Several huge parking lots were so packed that many cars were creatively parked on lawns and in unmarked spaces. Thousands of workers had been added just over the past few months. After visiting this giant complex, we went to a sister operation—another mammoth multibuilding facility opened less than a year ago. Even though the company makes only a few specialized microchips for its own systems, highly advanced semiconductor fabrication equipment has been installed in an immense clean-room complex, and the design section featured the latest engineering workstations. Elsewhere in the facility, technicians were assembling an advanced computer system based on custom microchips. In spite of its tremendous investment in integrated circuit development facilities, the company could still afford to contract out the design and fabrication of these custom chips to a commercial computer manufacturer.

The dramatic differences between the two facilities offered a quick glimpse of current national priorities. While money pours into military programs and production facilities, many U.S. industries are moving manufacturing offshore instead of automating domestic factories.

The Russians appear to be wrecking their economy by plowing resources into a military buildup while neglecting other industries. Do we have to copy them? Couldn't national policies be shifted to ensure that the United States' efforts to strengthen its military posture do not destroy its economic competitiveness?

Robert Haavind

highTechnology

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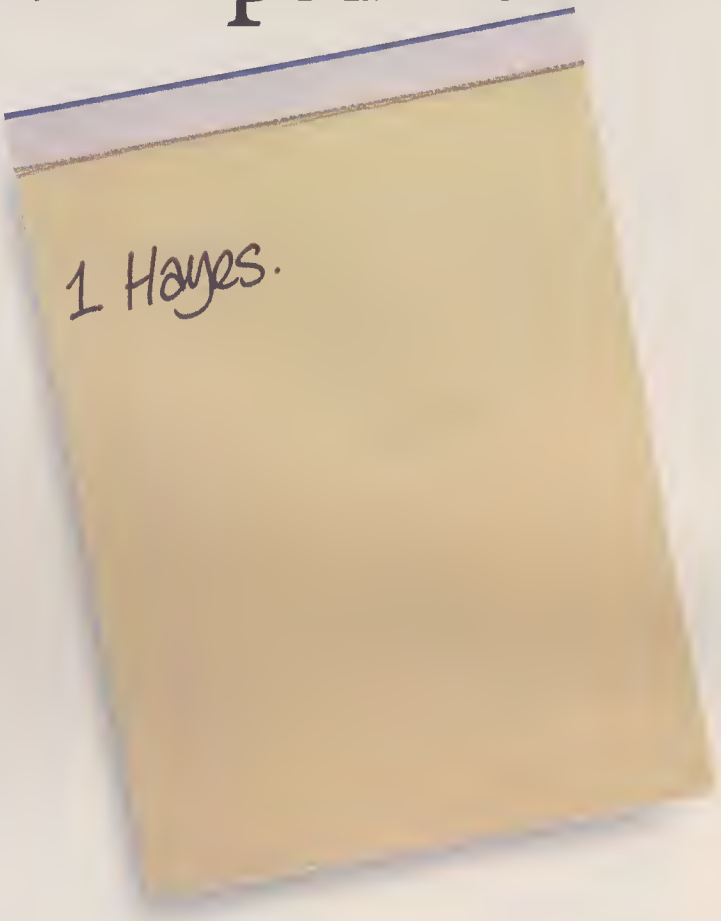

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LETTERS

Submersibles dive deeper

"Submersibles reach new depths" (Feb. 1986, p. 16) was an excellent overview of the industry and its exciting challenges. But I must comment about your assertion that the deepest diving ROVs (remotely operated vehicles) are currently limited to 6000 feet. Oceaneering's Dual Hydra 2500 is rated to 8200 feet and has made more than 200 working dives below 6000 feet. The deepest dive was 7002 feet, which is the world's record.

J. Wesley Rogers
President and CEO
Oceaneering International
Houston, Tex.

Oceaneering's Dual Hydra, shown in offshore trials near Santa Barbara, Cal.

The application of high technology to submarine robotics is creating ocean resource development opportunities at a time of critical need for U.S. industrial expansion. Your article on submersibles is an encouraging report on the evolution of underwater work-performance systems.

Edward Sherman Cole, Exec. Dir.
Aquatic Resources Development Laboratory
Ocean Foods Institute
Inkster, Mich.

Computer retailers irk campuses

Your article "Campus discounts irk computer retailers" (Feb. 1986, p. 67) contains several statements by Ronald Golesh, a computer dealer, that are misrepresentative. Mr. Golesh [whose company, Computronics, sued the University of Wisconsin–Madison after the school began selling Macintoshes in 1984] said that people come into his store every day trying to sell computers, and he can't check whether they come from the university's resale program. In fact, whenever members of its community reportedly violate the terms of computer purchase agreements, the university offers to check serial numbers for dealers.

Also, your article states that the U.S. District Court dismissed Mr. Golesh's case on an unrelated technicality. He was actually denied a temporary injunction to prohibit the university from selling computers while the case went to trial, and he later withdrew his case after several months of pretrial preparation.

In 1984, new computer stores opened in Madison; concurrently, the nationwide downturn in computer sales began. Dealers who saw sales plummeting were quick to blame university programs.

Tad B. Pinkerton, Director
Office of Information Technology
University of Wisconsin–Madison
Madison, Wis.

Editor's note: Tammi Harbert, the author, responds that although universities have offered to check serial numbers reported to them, computer dealers say the system is inconvenient. Instead, they want a list of the university machine numbers so they can check for themselves.

As a freshman attending Stevens Institute of Technology, I was quite alarmed when I read the views of computer dealers in your article.

Stevens requires all its incoming freshmen to buy the DEC Professional 350 microcomputer system, including a hard disk drive, 512 kilobytes of RAM, and a full complement of software. The full retail cost of the system is $9375, but through manufacturer's discounts and private funds, students are able to purchase it for $2100. I could never afford to attend Stevens if, in addition to the school's tuition, I had to pay the full cost of the computer.

Ken Ryan
Pine Brook, N.J.

A bid for efficiency

Your opinion "Correcting the mess in military procurement" (March 1986, p. 4) struck home. Recently I plowed through 63 pages of a bid specification for an addition to a central dial office at a military installation. Only three pages dealt with the actual requirements, and even these were incorrect and incomplete.

Two bids were submitted; ours was rejected because we "did not comply with the requirement for proposal format and content . . ."

Donald H. Dool, President
TeleTechnology International
McHenry, Ill.

Caveat emptor

Thank you for stating that "only typesetters yield true typeset quality" in "Micros get graphic" (March 1986, p. 18).

Members of the typographic community are very concerned over the recent flood of articles and advertisements claiming that low-resolution devices such as the Apple LaserWriter can produce true typographic quality. Trade typographers have a long history of buying hardware and software. We have learned that if one is gullible enough to believe all the hype, very costly mistakes can be made.

Betty Handly, President
Typographers International Assn.
Washington, D.C.

More joint ventures for MAbs

I read with interest "Monoclonal antibodies: promises fulfilled" (Feb. 1986, p. 32), but was surprised to see only one brief reference to Cytogen. In addition to Cytogen's joint venture with Farmitalia Carlo Erba SpA (Italy), it has agreements with American Cyanamid's Lederle Division for cytotoxic drugs for tumor sites; Johnson & Johnson for ferromagnetic materials used in magnetic-resonance imaging; and Cobe Laboratories for the use of monoclonal antibodies for removing immune complexes. In addition, the company will soon sign a major agreement in the nuclear-imaging field.

Robert F. Johnston, President
Cytogen Corp.
Princeton, N.J.

The straight dope on titanium silicides

I enjoyed your article "Better chips through chemical vapors" (Feb. 1986, p. 72) very much. Titanium silicides, however, are praised for their stability and low electrical *resistivity* characteristics, not conductivity.

Argenis Prieto, Development Engineer
Mepco/Electra
Mineral Wells, Tex.

Editor's note: Our article on scientific word processors, "Tools for manipulating symbols" (Feb. 1986, p. 57), erred in stating that cursor keys do not repeat with TCI Software's T3 program. In fact, users can set the cursor key repeat rate in the program.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110.

The signs of change.

If you've been to The Californias lately, you know there's a new momentum, a new attitude that has made change a part of public policy and public policy a part of change.

Yes, The Californias comprise the world's seventh largest economy. And, yes, we may be the fourth largest by the year 2000. But it won't be because we're lucky or nice. It will be because we made it happen.

We're taking care of business. We're making it easier.

Maybe that's why nearly thirteen hundred companies have located or expanded here in the last three years.

The signs are everywhere, and they all say the same thing.

They all say "Go."

The Californias

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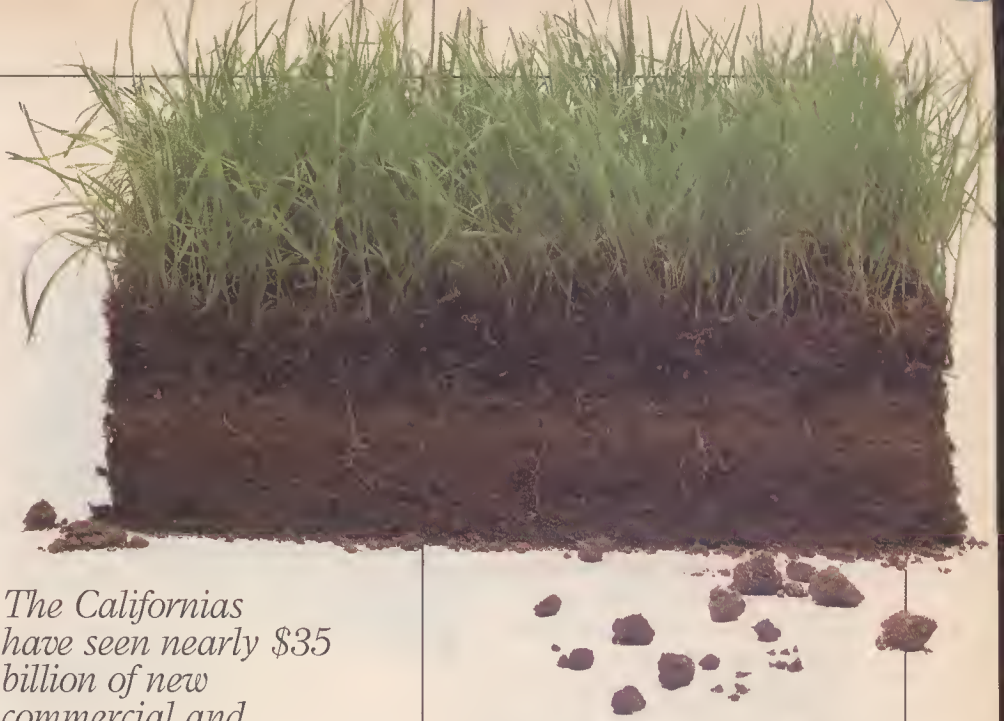
The Californias put more money into its public education system—grammar schools, high schools, universities and post-graduate schools—than any other state. We'll spend $21.6 billion this year. That's a 35% increase over three years ago.

Californians bought more retail goods in 1985 than Texas, Arkansas, Louisiana, and Oklahoma. Combined. Over $160 billion. (That's up 40% from 1980.) The state's total personal income for 1986 is forecast to grow 20% faster than the rest of the nation.

It takes a real leader to say this: The Californias are #23. In overall tax burden. In 1978, we were #4. We had a billion and a half dollar deficit in 1982. Now we have almost a billion dollar surplus. Without a general tax increase.

The Californias will spend $3 billion on streets, sewers, water delivery and related infrastructure this year. That's 1/3 more than 1984. (And an additional $16 billion expenditure before 1990 has been proposed.)



The Californias have seen nearly $35 billion of new commercial and industrial construction since 1980. But we still have all the land you need, at every price—including more fully-improved business parks than anywhere else in the world.

If you've priced office space in London, Tokyo or New York lately, $50 per square foot per year won't surprise you. Compare that with a ringside seat on The Pacific Rim for just $26 or $30 in Los Angeles or San Francisco.

UPDATE

Dial M for maven

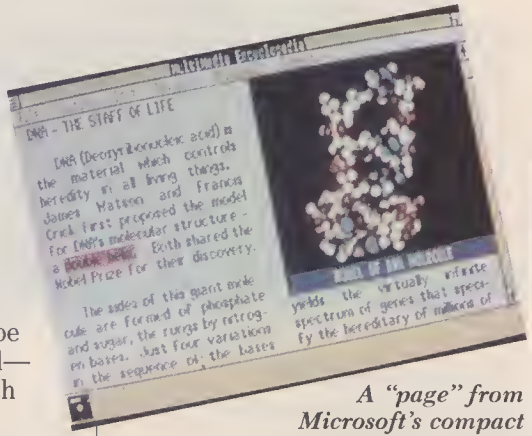
No matter how knowledgeable a company's technical staff is, questions inevitably arise that can't be answered in-house. Often they could be cleared up with a phone call—if only one knew how to reach the right specialist.

That's where Expert Access, a service launched last summer by Teltech Resource Network (Minneapolis), comes to the rescue. For a yearly fee ($3000–$7000, depending on a company's revenues), clients receive a roster of 400 engineers and scientists at universities and national labs or recently retired from industry. Clients can consult the specialists any time by phone (for $75) and, if necessary, can contract for more extensive work.

The service has already solved some knotty problems for many of the 40 clients signed up so far, says Teltech president Joseph Shuster. For example, an engineering firm was able to submit a bid that included an unusual welding specification after a welding expert provided the missing information. And a manufacturing company was able to avoid a potentially hazardous reaction between a plastic component and liquid oxygen by consulting a liquid oxygen specialist at one of the national labs.

Compact disc memory development heats up

Exhibitors at the first major conference on compact disc read-only memory (CD ROM), held recently in Seattle, demonstrated a host of new developments in this emerging technology. (CD ROM, the computer version of the audio compact disc, is being promoted for its ability to store large databases and associated data access programs.) Digital Equipment Corp. (Maynard, Mass.) showed its CD ROM drives for a wide range of personal computers. Publishing giant Grolier demonstrated its CD ROM version of the 20-volume *Academic American Encyclopedia*; this reference work, occupying a mere 20% of the 560-megabyte capacity of a single disc, is combined with database search software that makes information much easier to find than with a printed index. Perhaps the most impressive showing was a multimedia encyclopedia demonstration by Microsoft (Bellevue, Wash.), which mixed text with music, speech, photographs, graphics, and animation.



A "page" from Microsoft's compact disc multimedia encyclopedia.

Throughout the four-day conference, attendees discussed possible applications ranging from a phone book for the entire U.S. on one disc to a self-directed audio-visual tour of London with Alice-in-Wonderland-like "holes" where the viewer could drop into history and visit Shakespeare's or Dickens's London. (The latter is being developed by a division of Warner Records in Burbank, Cal.).

The conference, organized by Microsoft, drew nearly 1000 entrepreneurs and executives from the computer, information, publishing, and entertainment industries.

Chemical reduces fly ash from boilers

A fuel additive now becoming available in the U.S. promises to help industrial plants keep their boiler emissions legal. In a typical boiler, sulfur dioxide forms during combustion and binds with free oxygen, producing sulfur trioxide. If allowed to remain in the system, the sulfur trioxide gas combines with water molecules in the cooler regions of the furnace to create highly corrosive sulfuric acid. Naturally, boiler operators would rather get rid of the sulfur trioxide before this happens, so they use magnesium additives that combine with the gas and carry it out the stack as fly ash. The trouble there is that the increased particulate count often exceeds emission standards.

Kryda, a proprietary organic compound, can reduce the need for magnesium by 75–80%, according to Columbia Chase (Braintree, Mass.), the energy product firm that is marketing the additive in the U.S. The chemical inhibits the formation of sulfur trioxide by binding with vanadium, a trace metal found in fuel oils that catalyzes sulfur dioxide to sulfur trioxide. Because the resulting compound has no catalytic properties, most of the sulfur dioxide remains unchanged and is emitted as a gas. Emmanuel Psaltopoulos, manager of international operations, concedes that these emissions can still cause acid rain, but he says that state restrictions on the sulfur content of fuel oil ensure that they stay within legal limits.

Columbia Chase will import Kryda from R. Dona of Milan until demand is sufficient for U.S. production.

MICROSOFT

Before and after versions show how digital processing reduces the number of elements in part of a map. It links three areas of urban land (pink) and combines five patches of forest (purple) into two. The map will now be readable when shrunk.

Cutting maps down to size

The thousands of maps made each year are routinely scaled up or down in order to cover a broader or narrower area. Reducing the size of a map presents special problems, because cartographers want to retain accuracy while avoiding the illegible clutter that emerges when every detail is shrunk. As a result, the map must be painstakingly simplified by hand—a process that is expensive and often inconsistent. To solve this problem, the U.S. Geological Survey will soon begin using a computer program that selectively generalizes (eliminates detail from) maps, emphasizing features of interest while reducing overall size by as much as 90%.

First the mapmaker assigns weights to different types of terrain—such as forest, urban, or agricultural land—according to the type of map desired. Next, the computer superimposes a fine grid over the map (which is stored in a database), then overlays a much rougher grid, in which each cell covers, say, 100 of the smaller cells. The program counts the small cells of different terrain types within each large cell, gives them their appropriate weights, and assigns the dominant type to the entire large cell. It then moves row by row, bridging gaps in terrain by eliminating isolated cells and single lines of cells.

The technique may find application in other fields as well, according to its developer, Mark Monmonier, a professor of geography at Syracuse University. For example, he says, it could be used in generalizing satellite or medical images.

Drug could ease MS symptoms

It has been known for some time that the symptoms of multiple sclerosis, a degenerative disease of the nervous system, tend to recede in cold weather. Now, a drug that mimics one of the principal effects of hypothermia (lowered body temperature) appears to bring similar results. In preliminary testing at Rush Presbyterian St. Luke's Medical Center (Chicago), the organic chemical 4-aminopyridine temporarily relieved MS symptoms in 10 of the 12 patients treated. In some cases, says Floyd Davis, who heads the research effort, there was a dramatic improvement in motor control and sight. The effects lasted for up to four hours at a time.

The drug works by making individual nerve impulses last longer. In the nervous system, the electrical signals produced by a neuron are turned on by a flow of sodium ions across the nerve membranes and quickly turned off by a flow of potassium ions. The effect of cold weather—and of 4-aminopyridine—is to retard the potassium flow, thus delaying the conclusion of the impulse. The benefit to an MS patient, says Davis, is that the neurons can transmit more current to their damaged neighbors.

Davis says that although the drug's short-term side effects are known (they include a numbness of the fingers and a slight loss of balance), its long-term side effects are not. In addition, he stresses that the drug is only a palliative measure and that a lot more testing is needed before it can be approved by the FDA.

PCs get a human voice—for less

Talking computers are helpful for audio verification during data entry, for training new operators, and for use by the blind. But all except the most expensive voice synthesizers produce robotic speech that can be hard to understand. Now, a relatively low-cost voice synthesizer, Vert+ from Telesensory Systems (Mountain View, Cal.), can give personal computers a more human sound. One user, Brian Charlson, an instructor at the Carroll Institute for the Blind (Newton, Mass.), says the speech quality of the $2000 system "compares very well" with that of Digital Equipment's $4000 DECtalk, the industry's high-end standard.

Vert+ consists of a circuit board that plugs into an IBM PC and a floppy disk–based program that commands the unit to speak text by character, word, line, or page. It works with most off-the-shelf software, including Wordstar, Lotus 1-2-3, and Multimate. According to Telesensory VP Dan Gourney, the system's lower price results from its packaging as a circuit board—unlike DECtalk, which is a stand-alone peripheral—and from sizable orders by IBM and other large companies.

The Ten Deadly Sins

by Tom Peters

When high technology companies fall short of their potential, or go out of business altogether, the cause is seldom a lack of capital, financial control, imaginative engineering, or commercializable technology. Rather, it is management's inability or unwillingness to shift from a technology-centered to a customer-centered organization. In this regard, I have observed what I call the Ten Deadly Sins.

1. ***Failing to turn manufacturing into a marketing weapon.*** The start-up company cannot sustain itself long on the basis of gee-whiz science or technology. Because the factory, not the design shop, is the prime mover in selling and holding customers, forgoing exotica in favor of reliability and maintainability almost always produces winning results. For this to happen, though, top manufacturing management must be part of the design process from day one and must have equal status among high-level decision makers.

Wise executives further realize that manufacturing holds the key to domestic success. Flexible production geared to short runs allows the firm to get full benefit from their home-court, closer-to-the-market advantage. And because any product or product line should be seen as a continuing experiment, the factory should be the source of most intragenerational innovation. Significant product enhancement can result from the constant interaction of users, the sales/service/marketing function, and manufacturing—especially if manufacturing management is urged to spend substantial time in the field.

2. ***Undervaluing the intangibles of products.*** Harvard professor Ted Levitt, in *The Marketing Imagination,* describes the "total product concept," consisting of a product's generic attributes (instructions per second, for example, for a computer), its expected attributes (such as a reasonable mean time between failures), its augmented attributes (such as special features and compatibility with related products), and its potential attributes (all other intangibles, such as quality of service, in the relationship between vendor and buyer).

A key to success is the willingness to invest a large share of resources in a constant flow of small improvements.

My observation is that winners emphasize the augmented and potential attributes more than the generic and expected. Unfortunately, high technology firms tend to vastly underrate the augmented and potential attributes, although exceptions exist (for some strange reason, IBM comes to mind). Service, responsiveness, and relationship management are almost always undervalued by the "engineering mind-set" (as an engineer, I say this ruefully, to be sure). But the winning company's concern for the intangible is a reflection of the "customer mind-set."

3. ***Running the company "inside out" rather than "outside in."*** I'm told that product design engineers from top Japanese firms spend as much as six months per year on the road to get first-hand information from customers and salespeople. Talk about being in touch! By contrast, most technology-driven firms in the U.S. are far too inwardly focused, or "inside out." Getting an American design engineer outside the office more than three days a quarter seems to require an act of Congress.

Learning of opportunities is possible only if everyone's antennae, from the top of the firm to the bottom, are tuned outwardly—to suppliers, competitors, and customers. The next surprise in your market could well be happening as you read this—an innovative partnership, for example, between an unknown new firm and a small, aggressive user somewhere in the boondocks. But sniffing out these activities requires a thorough, all-hands "outside in" attitude, not just subscriptions to the leading industry newsletters.

4. ***Failing to invest in sales and service.*** Disrespect for field functions is rife among technology-based firms, where salespeople are too often seen as mere order-takers for our wonderful new breakthrough product. An investment of $5 million in new testing machines is made without hesitation, but an investment one-tenth that size in training and equipment for the sales and service team is viewed with unalloyed skepticism.

Ironically, the field team has customer contact and processes customer information day in and day out, and could therefore serve as a prime source of new product ideas. But I find from

Tom Peters is co-author of In Search of Excellence: Lessons from America's Best Run Companies *and* A Passion for Excellence: the Leadership Difference. *His management consulting company, The Tom Peters Group, is based in Palo Alto, Cal.*

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A new satellite provided the first telephone link between earthquake-stricken Mexico City and the Mexican consulate in Los Angeles, helping hundreds of anxious callers learn whether their relatives had survived the disaster. The consulate, located in the city with the largest population of Mexican citizens outside of Mexico City, was flooded with calls after the 7.8-magnitude quake on Sept. 19. For help, it turned to Hughes Aircraft Company, which had built the country's three-month-old Morelos communications satellite. Hughes engineers located a shipment of communications equipment en route to New York City and diverted it to the satellite ground station outside the Mexican capital. Meanwhile, an antenna at the Hughes ground station near Los Angeles was pointed at Morelos. To complete the phone line, the engineers established a microwave link between the ground station and company offices, then hooked into the local phone system to the consulate. The line was kept open 24 hours a day.

A new processing technique eliminates impurities in an optical fiber that has promising uses in the mid-infrared region of 1 to 5 micrometers. Zirconium fluoride glass fibers, which are typically prepared in an atmosphere of inert gases, contain defects that scatter light transmissions and preclude their use in long fiber links. Scientists at Hughes Research Laboratories, however, have prepared molten glass at 850°C using a novel reactive atmosphere process. This special process competely eliminates the chemical interaction with impurities, which yield light-scattering defects.

Although already advanced, North America's air defense system will be improved in the next few years to become even more vigilant in protecting U.S. and Canadian skies. The Joint Surveillance System, developed by Hughes for the U.S. Air Force, spans the continent from Alaska to Florida and Labrador to Hawaii. Already Hughes is developing a new computer, called the 5118MX, which has 3 million words of memory and will be at least three times faster than the current computer. Eventually, too, radar information from E-3A AWACS (Airborne Warning and Control System) aircraft will be fully integrated with JSS to expand coverage more than 200 miles beyond U.S. and Canadian borders.

A private, domestic satellite system will carry telecommunications throughout Japan beginning in early 1988. The system will be owned and operated by Japan Communications Satellite Company, Inc., a joint venture composed of Hughes Communications, Inc. (a Hughes subsidiary) and Japanese partners C. Itoh & Company, Ltd. and Mitsui & Company, Ltd. The joint venture firm has ordered two large, high-power satellites based on the new Hughes HS 393 spacecraft. These satellites will allow users to receive voice, television, and data transmissions through small, low-cost ground terminals. Each satellite will have 32 transponders, providing capability to transmit 32 channels of TV programming or a mix of TV and other communications. The satellites are scheduled for launch in December 1987 and April 1988. Services are expected to begin in February 1988.

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consulting assignments that it has become difficult to induce bold proposals from sales and service managers—not because they lack the skill, but because they're so battered from years of turndowns and contemptuous treatment.

5. *Starting to work too late on quality, reliability, and maintainability.* These attributes are not mere complements to technology; they constitute the long-term base for sustainable competitive advantage. Therefore quality, reliability, and maintainability concerns should drive most product and manufacturing-technology decisions, not vice versa. There is great wisdom, for example, in delaying release of a ballyhooed new product for reasons of quality or spare-parts availability, regardless of the fear that a competitor may take the market by entering earlier.

6. *Putting capital ahead of people.* Winning stems primarily from quality, service, and responsiveness. Capital can indeed enhance these attributes, but it is not their driver. To be sure, capital *was* the driver when mass, scale, and volume were the industrial watchwords. But all that is changing; a company's staff is increasingly being recognized as its most valuable asset. Labor relations for high technology firms should therefore progress beyond treating the so-called "gold collar" PhD software engineer like a king while allowing all other employees to live in fear of capricious layoffs. The people who make and distribute the product should be respected and supported as well.

7. *Having too slim a portfolio of "small beginnings."* Far too many technology-based firms wait anxiously for their founder or star designer to come up with the next miracle product. But that's not the way innovation occurs. Multiple starts, multiple centers of innovation, and a willingness to invest a large share of resources in a constant flow of small improvements are the keys to success. Hewlett-Packard, for instance, maintained the viability of its 3000-series computer for years after the experts said it was obsolete. Its continuing success came from a sizable investment in a myriad of minor customer-driven adaptations.

8. *Waiting too long to decentralize.* The organizational structure is often taken for granted by the executives of young firms. Consequently, they wait far too long to decentralize—or, having decentralized once, they fail to keep spinning off new units. Steep hierarchies can thwart the best of intentions concerning responsiveness to customers; the ultraflat corporation with numerous semi-autonomous units is by nature a more customer-minded entity.

9. *Failing to take full advantage of international markets.* Huge foreign sales opportunities are often available from the outset for the high technology firm, but they often go unrealized. Many young—and, sadly, not so young—companies do not bother to appropriately tailor their products for international markets or build local infrastructures that can provide service and manage customer relationships. For instance, after 95 years of selling products to Japan, Kodak just made its first substantial offshore investment there.

10. *Believing that complexity and bureaucracy must accompany growth.* The customer-centered company is marked by fleetness of foot, which always stems from extraordinarily good communication in small, decentralized units. Yet corporate advisers urge the growth company to professionalize and systematize. There is some validity in this advice, but its practical effect in most cases is to gut the firm's inherent competitive advantage.

Systematize as you must, but do not let that keep marketers from spending half their time in the field (bureaucracy often bogs them down in reports) or top executives from taking customer phone calls ("He can't be disturbed; he's in a meeting"). Some bellwether firms are proving that a corporate staff of ten with no manuals or job descriptions can profitably run a billion-dollar operation.

The point of this brief tour is to emphasize that the Ten Deadly Sins can be avoided. Technology-based firms can build their own rosy futures—in spite of the trajectories of foreign competitors or other factors beyond their control—by recognizing where their own strengths lie and by wisely directing them. They can become, or remain, truly customer-centered. □

Artificial Intelligence Corp:
TEACHING COMPUTERS PLAIN ENGLISH

One of the few areas in which artificial intelligence is actually being applied to business problems is natural language processing—a technology that allows people to communicate with computers in ordinary English. In the mainframe part of the market, Artificial Intelligence Corp. (AIC), a ten-year-old privately held company in Waltham, Mass., is by far the dominant vendor. And with $7 million in revenues for the year ended in March, it has a sizable share of the entire natural language business, estimated by market research firm DM Data (Scottsdale, Ariz.) at $59 million in 1985 and worth a possible $650 million by 1990.

AIC's main product is a program called Intellect, used almost entirely with large database management systems both to give programmers more flexibility and to provide nonprogrammers with direct access to stores of corporate information. Intellect, which sells for $34,000–$125,000, depending on options, translates conversational language into code used by the database management system. It understands, for instance, that the phrase "Give me a list of our New York salespeople" has the same meaning as "Who is selling our product and is based in New York?" In either case, it will ask whether New York refers to the city or the state before translating the request.

Much of AIC's commercial success, says founder and president Larry Harris, is due to the joint marketing of Intellect with database management systems and the computers that run them. In the early 1980s, AIC made agreements with Control Data and Boeing Computer Services to market the program to their database time-sharing customers. A 1983 pact with IBM was particularly important in two ways: It opened a huge potential market; and, because this was IBM's first agreement to sell software not written in-house, it generated a spate of publicity for AIC.

Since then, the company has joined forces with Cullinet Software (the leading supplier of general-purpose database management systems), with Digital Equipment (the leading maker of minicomputers), and with leaders in several specialized segments of the database management system market. These include Shared Medical Systems in the medical field, Information Science in the personnel field, Information Builders in the library field, and Teradata in the field of computers customized for databases. AIC also sells directly to Fortune 1000 companies and government agencies, where it has installed 400 copies of Intellect.

Harvey Newquist, an analyst for DM Data, points out that Intellect has few direct competitors. Although more than 50 software companies and a few large computer companies are developing natural language products, virtually the only other vendors to have penetrated the mainframe market, he says, are Martin Marietta Data Systems (with its Mathematica Group product line) and Frey Associates (with Themis).

AIC has announced its intention to plunge into the high-volume personal computer software market as well, where it would face more competition. But a PC version of Intellect, which had been expected in 1985 by some industry watchers, has been "put on hold" for another year, says Harris, because of the PC market's recent instability. Part of the problem may be in determining how to position this product against the under-$1000 natural language programs for PCs from Texas Instruments, Microrim, and Symantec. Harris claims AIC's package will be more powerful, but acknowledges that it will undoubtedly be priced much higher.

Also in the wings is a system under joint development with Kurzweil Applied Intelligence to tie natural language processing to a voice recognition system. The partners are already testing a prototype that allows users to direct computers with spoken commands, says Harris. A commercial version is still years away, but AIC seems content to expand slowly. Despite its restraint—or perhaps because of it—the company is one of a handful in the AI field to have moved out of the red. "We're conservative," Harris says, "but we sell to a conservative market: users of mainframes."—***Mary Jo Foley***

Natural language software helps give nonprogrammers direct access to corporate data. For example, AIC's Larry Harris points out that the sales graph shown was obtained with the simple one-sentence command at the bottom of the screen.

JON GOELL

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Liposome:

PUTTING DRUGS IN TINY BUBBLES

Bringing a novel drug-delivery system to market is the goal of Liposome, a five-year-old biotechnology firm in Princeton, N.J. Substances like insulin or human growth hormone could be packaged within microscopic bubbles called liposomes, which—when injected into patients—could steadily leak the drugs for two or three weeks. Liposomes have walls that consist of double layers of lipid (fatty) molecules very similar to biological membranes. Some of the bubbles have one wall surrounding a pocket of water; others have several concentric walls, resembling the layers of an onion. Drugs loaded either into the pockets or between individual layers leak out as the lipid walls are metabolized within the body.

Although lipids' ability to form tiny bubbles was discovered over 20 years ago, most biologists thought they couldn't be commercially used for drug delivery because the bubbles were so short-lived. And it was far from certain whether they could be coaxed to contain drug molecules at all. But three companies—the biotechnology lab Whitehead Associates, International Nickel subsidiary Inco Securities, and venture capital firm North American Ventures—were willing to invest some money to solve the problems and set up Liposome as a joint venture. The gamble paid off: Less than two years after its inception, the company developed a stable, long-lived liposome that could entrap drugs and was also relatively inexpensive to produce. The original investors have since been joined by Monsanto and Eli Lilly, as well as such venture capital firms as Venrock Associates, DSV Partners, Adler & Co., and Kleiner Perkins Caufield & Byers.

The subsequent patent Liposome was granted was not only the company's first but also the first patent for any liposome product. Other companies, such as West Coast start-ups Liposome Technology and Vestar, have since entered the field, but Liposome—with the largest staff, the longest history, and the most financial backing—is considered very much the industry leader, says Linda Miller, assistant VP and biotechnology analyst at PaineWebber (New York).

Still, the company has yet to bring a product to market. And it will be at least several years before the first products for human use complete trials, which are scheduled to begin only this year. Even though liposomes aren't pharmaceuticals per se, they must go through a long FDA drug-approval process for each individual drug cargo. The reason is that delivering a drug in a liposome can dramatically change the drug's effectiveness and toxicity.

The company is in fact trying to exploit this phenomenon by increasing the magnitude of liposomes' positive effects on many drugs, says Marc Ostro, Liposome's vice-chairman and chief science officer. In the case of certain cancer drugs, for example, liposomes may be able to buffer toxicity so that patients can withstand higher doses and suffer fewer side effects. The bubbles can also help prevent topically applied drugs from being washed or brushed away; products are under development for use on the eyes, skin, mouth, nose, throat, vagina, and rectum, says chairman and CEO Edgar Mertz.

Yet another application is encapsulating proteins that degrade rapidly when injected into the body; these include interferon and other immune-system agents, as well as substances such as insulin and human growth hormone. Protected within multilayered liposomes and gradually metabolized in, say, a muscle, these fragile substances can be slowly and steadily released.

The company is also experimenting with sending liposomes to specific sites of infection via scavenger white blood cells called macrophages. Although many drugs can't be absorbed by macrophages at all, these cells will swallow liposomes, even loaded with otherwise unabsorbable drugs. This "macrophage loading" technique has already been successful in delivering antibiotics to sites of infection in several animal experiments.

Liposome so far has four veterinary field trials under way with joint venture partners and expects to initiate several clinical trials for human products in the near future. Most of these will also be joint ventures, although the company hopes eventually to finance more of its projects alone. With the painstaking pace forced by the regulatory process, it could take another five years for Liposome just to break even, acknowledges Mertz. What keeps the company's spirits—and those of its backers—from flagging is the potential reward: a share of the market for drug delivery systems, which Mertz estimates will top $5 billion by the end of the 1990s.

—Ricki Lewis

American Solar King:

SOLAR SPECIALISTS SWITCH TO GAS

When Congress failed to renew solar energy tax credits at the end of 1985, it may have pulled the plug on the young industry. Many firms that had managed to stay in business despite dropping oil and gas prices aren't expected to survive this latest blow. But American Solar King (ASK)—since 1983 the country's leading manufacturer of solar collectors—has mapped a survival strategy that industry watchers believe may well succeed. Building on a three-year, $2 million R&D program in solar-powered cooling systems, the Waco, Tex., company has designed a gas-fired residential air conditioning and heating unit called Energymaster that it claims will be 10–30% less costly to operate than electrically powered combination units currently on the market.

ASK is pinning its hopes on Energymaster because it expects its revenues from solar water heaters to plunge below $10 million this year, from $30 million in fiscal 1984. Martin Enowitz, an analyst for Energy Investment Research (Greenwich, Conn.), says that this sharp decrease in sales is largely attributable to the expiration of tax credits. Hardest hit have been sales of commercial and industrial systems, which ASK president Brian Pardo believes will "essentially disappear," although they previously accounted for more than half of the

company's total revenues.

Originally designed for use with solar collectors, Energymaster is driven by water heated to 140–160° F. A four-ton solar unit was expected to sell for $11,500. But without federal (and often state) tax credits, this price became far too expensive to compete with high-efficiency electric heat pumps that provide cooling and heating for $5000–$6000 installed. But by replacing solar collectors with a gas-fired water heater, the system price drops to less than $6000 installed. ASK's initial market area will be the Southwest, where demand for cooling is high, where the dry climate helps the system function efficiently, and where ASK has most successfully sold solar water heaters in the past.

Energymaster will be marketed directly to consumers and through the traditional gas appliance dealer network. It may be a hard sell, however, because the concept of gas-fired air conditioning is completely new to most homeowners, even though gas-fired cooling systems from Yazaki, Sanyo, and Hitachi are making inroads into the commercial market. But the company may get a big assist from the gas industry. Gas-fired cooling equipment is of great interest to the gas industry, says Ken Cuccinelli, VP of marketing for the American Gas Association (AGA), because "gas demand falls dramatically in summer, leaving distribution systems underutilized." If Energymaster passes a battery of performance and safety tests now being administered by the AGA, the product will be added to its promotion program, which includes cooperative advertising as well as installer training, distribution of information to engineers and architects, and assistance with local building code procedures. Many local gas utilities may also include Energymaster in their low-cost financing programs for appliances.

Making the transition from a solar to a gas-appliance company won't be easy, contends analyst Enowitz, but the gas industry's help will raise ASK's probability of success considerably. Even if it can make the transition, ASK doesn't intend to abandon its solar business. "I'm still personally committed to solar energy," says ASK's Pardo. But if his company is to stay healthy, it will have to be powered by gas.

—Kevin Finneran

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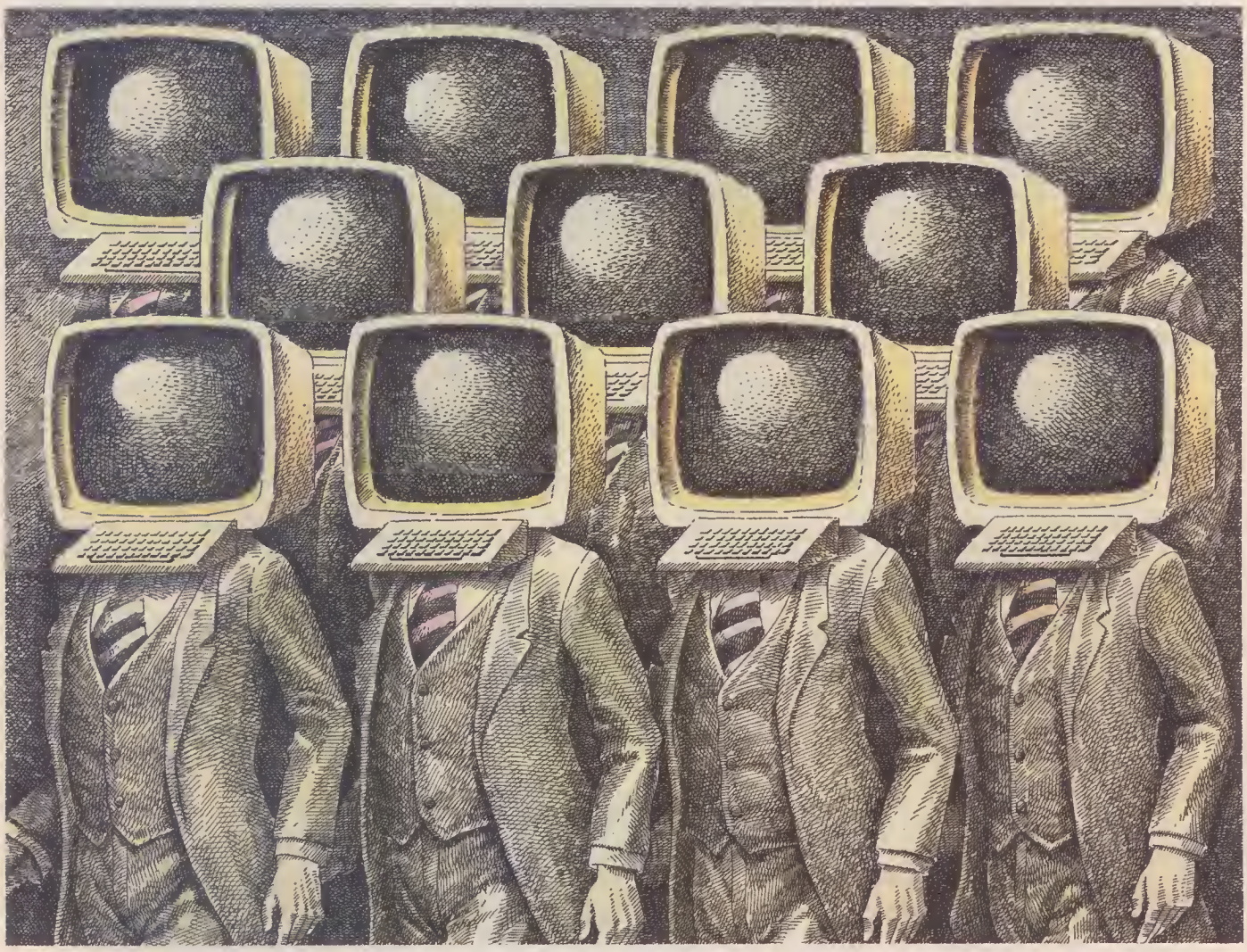

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Communications has become a critical component of corporate strategy. Without assured access to reliable voice links, few companies could conduct their business. And the ability to compete and grow has increasingly come to depend on the quick and accurate transmission of computer-based data. At the same time, the business of managing telecommunications has become more and more complex. Technological innovations have been rampant, and AT&T's divestiture has opened the market to hundreds of new vendors pushing a wide variety of products and services.

In the Special Report that follows, HIGH TECHNOLOGY explores how companies are taking advantage of the new situation—or at least trying to cope with it—in order to meet their telecommunications needs as effectively and inexpensively as possible. Many are bypassing the traditional local systems, long-distance networks, or both, with their own private links. Others are sharing private networks, either by engaging third-party providers or by essentially going into the communications business themselves. And others continue to use the public networks exclusively, often in response to new services that the local phone companies and major long-distance carriers have been introducing in order to compete against the bypass options.

Highlighting the report is a panel discussion with five industry experts—three telecommunications managers and two leading consultants. Included in their wide-ranging analysis are the major operational issues facing telecommunications users today, as well as some of the applications that new networks are beginning to make possible.

THE BYPASS CONNECTION

Lured by lower rates and better service, business users are turning to private phone links

by Lawrence Gasman

Large U.S. businesses are increasingly taking a do-it-yourself route to telecommunications. They are building or leasing alternative communications channels to bypass the facilities of local telephone companies, long-distance carriers, or both. And the new bypass facilities are tailored to provide companies with the type of communication they need most—whether it be direct links with their corporate offices or cheaper connections to distant clients. What's more, these bypassers in the business community—manufacturers, banks, railroads, and utilities, for example—are being emulated by government agencies and academic institutions.

Private networks are nothing new; they have been around since 1959. But changes in the economics of telecommunications since deregulation have provided new financial incentives to bypass, and the level of activity has grown accordingly. A recent study by the accounting firm of Touche Ross & Co. (Washington, D.C.) determined that 25% of all large businesses are already bypassing and that this figure should rise to 50% by 1987. The Conference Board, an economic and management research group based in New York City, reports that 31% of Fortune 500 companies bypass. Naturally, these statistics are causing much consternation at the local telephone companies, whose facilities are most likely to be bypassed. Although some long-distance bypass is occurring as well, long-distance carriers are less concerned than local telephone companies, because they usually make up lost revenues by leasing lines to bypassers.

Despite some of their more apocalyptic predictions, the local phone companies stand to lose only 5% of their revenues to bypass, according to the market research firm International Resource Development (Norwalk, Conn.). Companies using bypass will still make

substantial use of the public switched network, both local and long-distance, for external communications with customers and suppliers.

Indeed, rather than lose business, the local telephone companies are themselves becoming vigorous bypassers. Illinois Bell (Chicago), for example, has begun to set up a microwave network for data and voice transmission that will effectively bypass its own local loops in Chicago. The new network will provide a less expensive high-speed route for Illinois Bell's large customers, thus preventing a potential loss of business to private bypass links. New York Telephone and Southern New England Telephone (New Haven, Conn.) have both set up private fiber optic networks for local service for large customers; New York Telephone estimates that it saved Prudential-Bache Securities 60–80% on local phone costs by leasing a fiber optic network between the firm's offices in the New York City area. Another Bell company, Pacific Telesis (San Francisco), has built a fiber optic network specifically to serve San Francisco's financial district.

In the most common approach to bypass, called service bypass, the customer leases private lines from the local telephone company to reach the long-distance carrier directly. These private lines usually operate at the T1 rate (1.544 megabits per second, or Mbps), which can support many channels of both data and voice transmission. And because only leasing costs apply on these lines—there are no switched access charges—leasing a T1 link costs about $1000–$1500 per month (a saving of up to 50% over the equivalent number of switched lines).

For users who wish to build their own bypass links, several alternatives are available, but microwave has been the technology of preference. It is a thoroughly tested system with many well-established suppliers such as Harris's Farinon Division (San Carlos, Cal.), Ericsson (Garden Grove, Cal.), GTE (Stamford, Conn.), NEC (Fairfax, Va.), and Northern Telecom (Stone Mountain, Ga.), as well as some lesser-known companies such as Digital Microwave (Santa Clara, Cal.), and Avantek (Milpitas, Cal.).

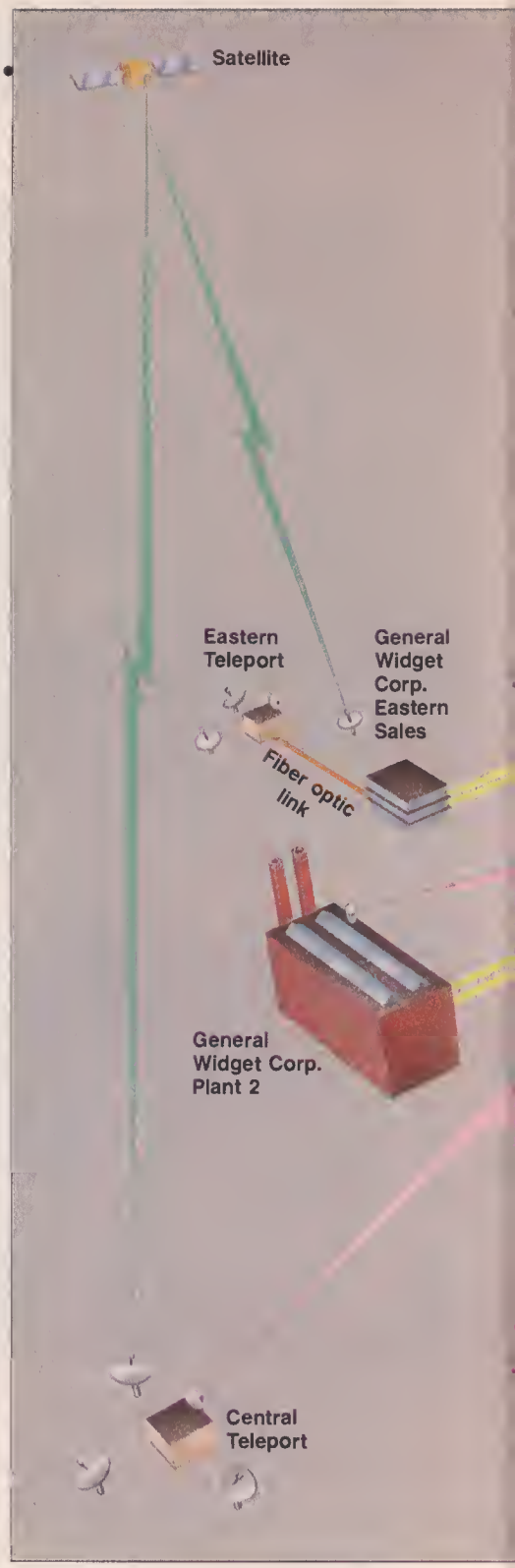
Point-to-point microwave is relatively inexpensive to set up and maintain—about $25,000 per link, including installation, according to Robert P. Bernardi, chairman and CEO of Spectrum Digital (Herndon, Va.), a company that supplies private microwave gear. However, the effect of long-term exposure to microwave radiation is rapidly becoming an issue in some heavily populated areas.

From a technical standpoint, the major limitation of terrestrial microwave transmission is the need for a clear "line of sight" between microwave towers. Microwave is therefore most suitable for medium-haul routes, typically 10–20 miles in a suburban environment. In some cities, though, the proliferation of microwave bypass is reaching the point where it is likely to slow down because of frequency spectrum crowding.

One bypasser using private microwave is Ebasco Services, a New York–based engineering firm. Ebasco uses a Harris Farinon microwave terminal and a two-foot parabolic antenna to send communications from its offices on the 77th floor of New York's World Trade Center to a rooftop antenna six-tenths of a mile away, operated by Satellite Business Systems. (SBS, a long-distance carrier based in McLean, Va., offers private satellite links for high-volume voice and data customers.) From there the signals are relayed to their destination. According to Nancy Raccuia, Ebasco's supervisor of communications, Ebasco took the bypass route because of problems with the quality and availability of private lines from the local telephone company. And it chose microwave, she says, because "there was no other alternative. With cable-based systems, one immediately runs into right-of-way problems."

Nevertheless, a few organizations have built their own private communications networks based on fiber optic cabling. In 1987, for example, the University of Iowa (Iowa City) will begin operating a $15 million fiber optic network that connects five locations. And Hercules, a chemical company based in Wilmington, Del., installed fiber optic links between three locations in Delaware's New Castle County. This network will complement the firm's already operational satellite-based communications system. And Aetna Life and Casualty Co. (Hartford, Conn.) has three locations in Connecticut linked by optical fiber as part of a video-conferencing scheme. The Aetna network was supplied by Southern New England Telephone, Aetna's local phone company.

Although cable-based bypass potentially offers much higher bandwidths than private microwave, few end users can get around the right-of-way problems of cabling or justify the economics of building their own fiber optic networks. But an independent cable system owner, such as a cable television company, could efficiently connect several users to a long-distance carrier. Cable companies are well established throughout the U.S. and could, in theory, charge on a marginal cost basis,



What's good for General Widget

The voice, data, and video communications demands of General Widget Corp. (a made-up company) call for a wide variety of conventional phone links and bypass options. A bypass to the company's computer center (purple) is provided by wires leased from the local cable TV company. GWC also leases private lines (red) from the local phone company to allow direct links to the long-distance carriers for the HQ and the Western Sales offices. A bypass to the Eastern Sales offices is made via satellite links (green) provided by teleports. GWC has its own microwave network (pink) tying the HQ directly to the Central Teleport, as well as to GWC's two main manufacturing plants, thus bypassing the local phone company. In the East, the local telephone company provides a fiber optic link (orange) from the Eastern Teleport to GWC's Eastern Sales. Despite its reliance on bypass, GWC still makes extensivc use of the conventional local loops (yellow) and long-distance networks (blue) for communications with customers and vendors.

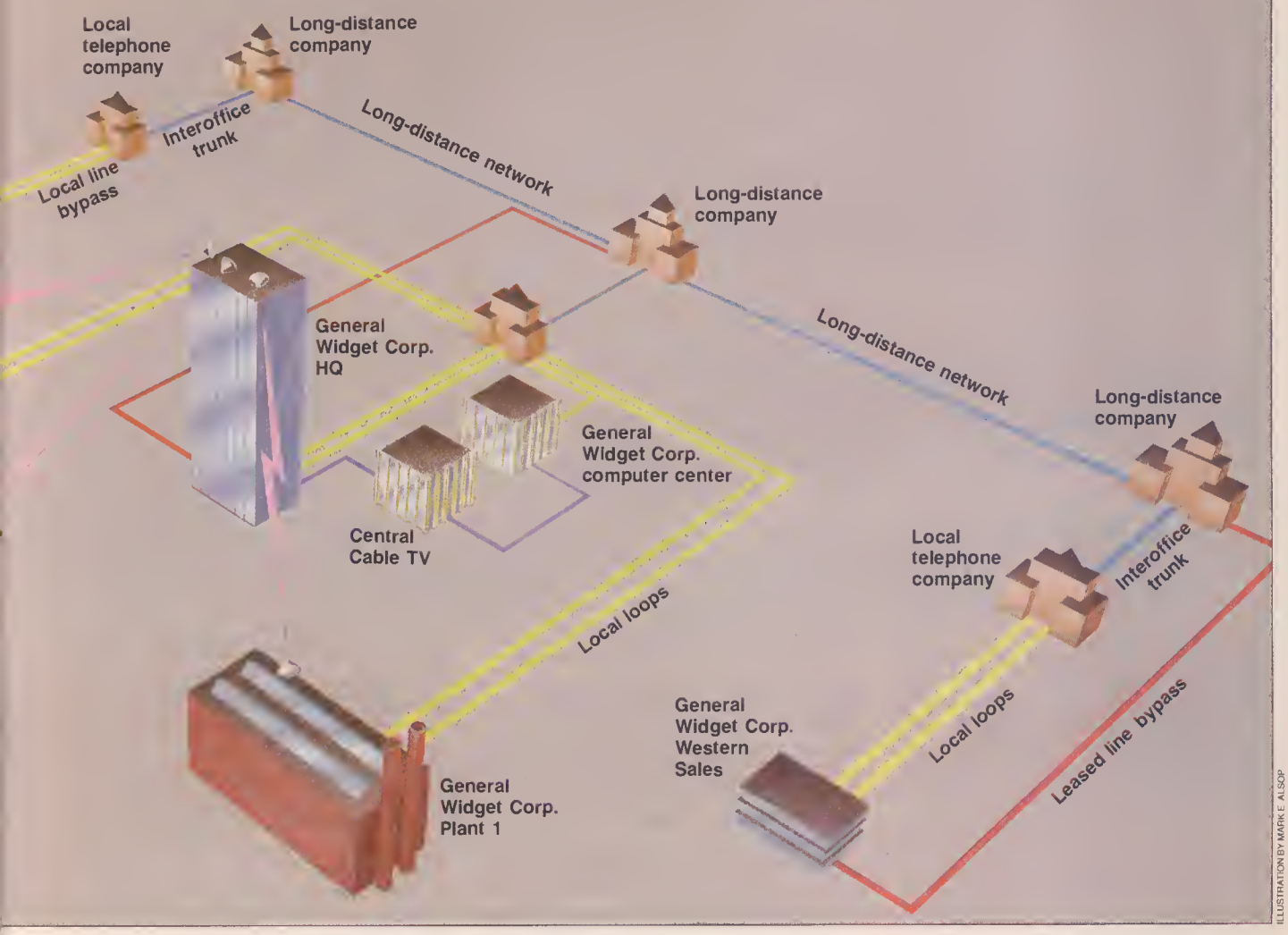


ILLUSTRATION BY MARK E. ALSOP

since most of their capital costs are covered by their basic entertainment functions.

The telephone companies have in fact long been fearful that cable television companies would get into the bypass business in a big way, but this has yet to happen. For one thing, cable companies have been reluctant to compete with the local telephone companies' public switched service, for fear of encountering regulatory hassles with the FCC.

Cable companies also face several physical and technical problems, according to Victor Krueger, vice-president of the Telecommunications Industry Services Division of Dataquest, a market research firm in Cupertino, Cal. In most cities, he notes, cables run through residential rather than business districts. And because cable systems are generally built to handle one-way entertainment channels, they cannot offer the interactive two-way communications needed by businesses; where cable companies offer bypass,

The economics of bypass

The biggest incentive for local bypass is economic—the reduction in the cost of connecting users to long-distance services. At present, both the long-distance companies and the end user must pay access charges to the local telephone company. Long-distance companies pay a common-carrier line (CCL) charge designed to help the local phone company pay for the fixed costs of the local loop; at present, it is 4.33¢ per minute at both the originating and terminating ends of traffic. For example, if a one-minute conversation between New York City and San Francisco involves GTE's Sprint network, Sprint pays New York Telephone 4.33¢ and Pacific Bell 4.33¢. Because calls that bypass the local phone companies also bypass these charges, the long-distance carriers can offer lower rates to end users who bypass. However, the end user also pays the local company a flat access fee for connection to a long-distance carrier. This fee is currently $1 per month for residential and single-line business users (soon to be raised to $2) and $6 per line for multiline business users. These charges are usually considered "bypass neutral" because, unless the user is not connected to the local phone company at all (which is a practical impossibility), the fees cannot be avoided.

The local telephone companies argue that if the user access fees were sufficiently high, the CCL charge could be lowered to a point where the amount saved through bypass would be insufficient to encourage the practice. The local companies would then retain their customers and would not have to raise rates (to non-bypassers). In theory, the average user could wind up with a lower total bill despite the higher access charges. Bypass would then become a matter of the local telephone companies and their competitors trying to win over large business customers on the basis of data rates, availability of channels, and service.

The FCC, too, would like to see access costs borne to a greater degree by business and residential consumers, but this proposition is not politically popular. As an interim measure, the FCC has suggested shifting the burden of the CCL charges to the terminating end of the conversation so that they could not be avoided by bypass at the originating end.

The local telephone companies are anxious to reform rates in any way they can. For example, NYNEX, the northeastern regional Bell company, has proposed a major restructuring of its pricing policy, with costs shifted to the end user and discounts for large-volume customers. California's Pacific Bell has filed for a new rate structure that would reduce the incentive to bypass. And in a move that has sparked questioning from consumer groups, Southern Bell and South Central Bell, both units of BellSouth, are offering their major customers special discount rates and services. Meanwhile, the public service commissions in Wisconsin, Idaho, Kentucky, and New York are all sympathetic to the idea of lowering access charges for large business users.

they do so over cable especially laid for this purpose. In any case, says Krueger, most cable companies are "not well off or sophisticated enough" to enter the business communications market.

The cable company that seems to have made the most progress in the bypass business is New York's Manhattan Cable TV (MCTV), which began experimenting with data transmission as early as 1974. It offers users point-to-point and point-to-multipoint links supporting communications at data rates up to the T1 standard. MCTV claims that the New York City government, which recently switched over from New York Telephone's lines, has been able to reduce its data communications costs by 33%. MCTV also offers videoconferencing and plans to supply its customers with uplinks to satellites from its midtown Manhattan headquarters.

For users who wish to build their own networks but lack the resources, an alternative is to share a bypass link. Some companies with large private networks are already leasing unused capacity to smaller users. For example, Sears Roebuck (Chicago) and Boeing (Seattle) have gone into the telecommunications business by offering access to their private networks. But shared bypass is more likely to be offered by specialist providers, such as the teleports now springing up around the country (see "Teleports: at the crossroads," p. 28). For example, the New York Teleport already has local fiber optic links to about 30 large mid-Manhattan buildings. Under these arrangements, the end user's traffic is directed to the local facilities of the bypass carrier through a private local network; on receiving the signal, the teleport transmits it via satellite.

Another approach to shared bypass is the digital termination service (DTS). With DTS, subscribers are linked by terrestrial microwave to a central node, typically one per city, from which the transmission is relayed by satellite or point-to-point microwave to a central node in another city. Unlike teleports, which are intended for long-distance use and typically offer a range of linking technologies, DTS is used for relatively short-haul communications, and its local links are restricted to microwave, within a narrowly defined frequency spectrum. Long-distance carriers such as Satellite Business Systems and local operating companies such as Pacific Telesis and Illinois Bell are building DTS systems. Smaller independent vendors have also appeared; Digital TranService Corp. (Dallas), for example, provides DTS service in Dallas, Cincinnati, and Chicago, and has obtained construction permits or license rights for operations in 20 other U.S. metropolitan areas. Local Area Telecommunications Corp., or Locate, provides a similar service in Manhattan; one customer, Securities Industries Automation Corp. (part of the New York Stock Exchange), uses Locate's facilities as a link from its downtown computer center to the Stock Exchange on Wall Street. Locate is expanding to more than a dozen other cities as well.

Another form of joint use that has great potential for bypass is Shared Tenant Services (STS), under which a telecommunications facility such as a private branch exchange (PBX) is shared by tenants in a multiple-occupancy building. Some 400 buildings in major cities across the country are now equipped with this service. While STS does not implicitly involve bypassing the local telephone company, an STS company with appropriate switching facilities could easily take the next logical step and provide its tenants with cheap microwave or fiber optic links to a long-distance carrier. AT&T is particularly well equipped to do this since it is a leading provider of both STS and long-distance service.

For long-distance bypass, end users can lease a range of services—anything from a voice-grade channel to a 1.5-Mbps channel—from a handful of satellite carriers such as SBS, RCA Americom (Princeton, N.J.), GTE Spacenet (McLean, Va.), and American Satellite (Rockville, Md.). SBS's Communications Network Service, for example, uses its

Telecommunications Reader Survey

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1. Are you involved in the specification or acquisition of voice communications equipment? ☐YES ☐NO
2. Are you involved in the specification or acquisition of data communications equipment? ☐YES ☐NO
3. Does your company own/lease or plan to buy/lease any of the following equipment or services?

	Currently own/lease	Plan to buy/lease in the next 24 months
a. Private branch exchange (PBX)	☐YES ☐NO	☐YES ☐NO
If yes, how many lines?	_____ NUMBER OF LINES	_____ NUMBER OF LINES
What are your PBX communications capabilities?	☐Voice ☐Voice and data	
b. Local area network (LAN)	☐YES ☐NO	☐YES ☐NO
If yes, how many nodes?	_____ NUMBER OF NODES	_____ NUMBER OF NODES
c. Modems	☐YES ☐NO	☐YES ☐NO
If yes, how many modems (by speed)?		
300–1200 baud	_____ NUMBER OF MODEMS	_____ NUMBER OF MODEMS
2400–4800 baud	_____ NUMBER OF MODEMS	_____ NUMBER OF MODEMS
9600 baud or above	_____ NUMBER OF MODEMS	_____ NUMBER OF MODEMS
d. Multiplexers	☐YES ☐NO	☐YES ☐NO
If yes, how many?	_____ NUMBER OF MULTIPLEXERS	_____ NUMBER OF MULTIPLEXERS
e. T1 equipment/services	☐YES ☐NO	☐YES ☐NO
f. Fiber optic equipment (on site)	☐YES ☐NO	☐YES ☐NO
g. Microwave links	☐YES ☐NO	☐YES ☐NO
h. Satellite communications	☐YES ☐NO	☐YES ☐NO
i. Value-added carrier services	☐YES ☐NO	☐YES ☐NO

If yes, which services do you require (check all that apply)?

☐Packet-switched transmission ☐Protocol conversion ☐Error-free transmission
☐Electronic mail ☐PC to mainframe links ☐Other (specify) _____

4. What major telecommunciations problems face your company in the next 24 months?

_____

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5. What is your company size? a. Annual sales _____ b. No. of employees _____
6. What is the primary business of your company? _____
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9. Do you wish to be contacted by manufacturers of telecommunications equipment or services? ☐YES ☐NO

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CHUCK O'REAR

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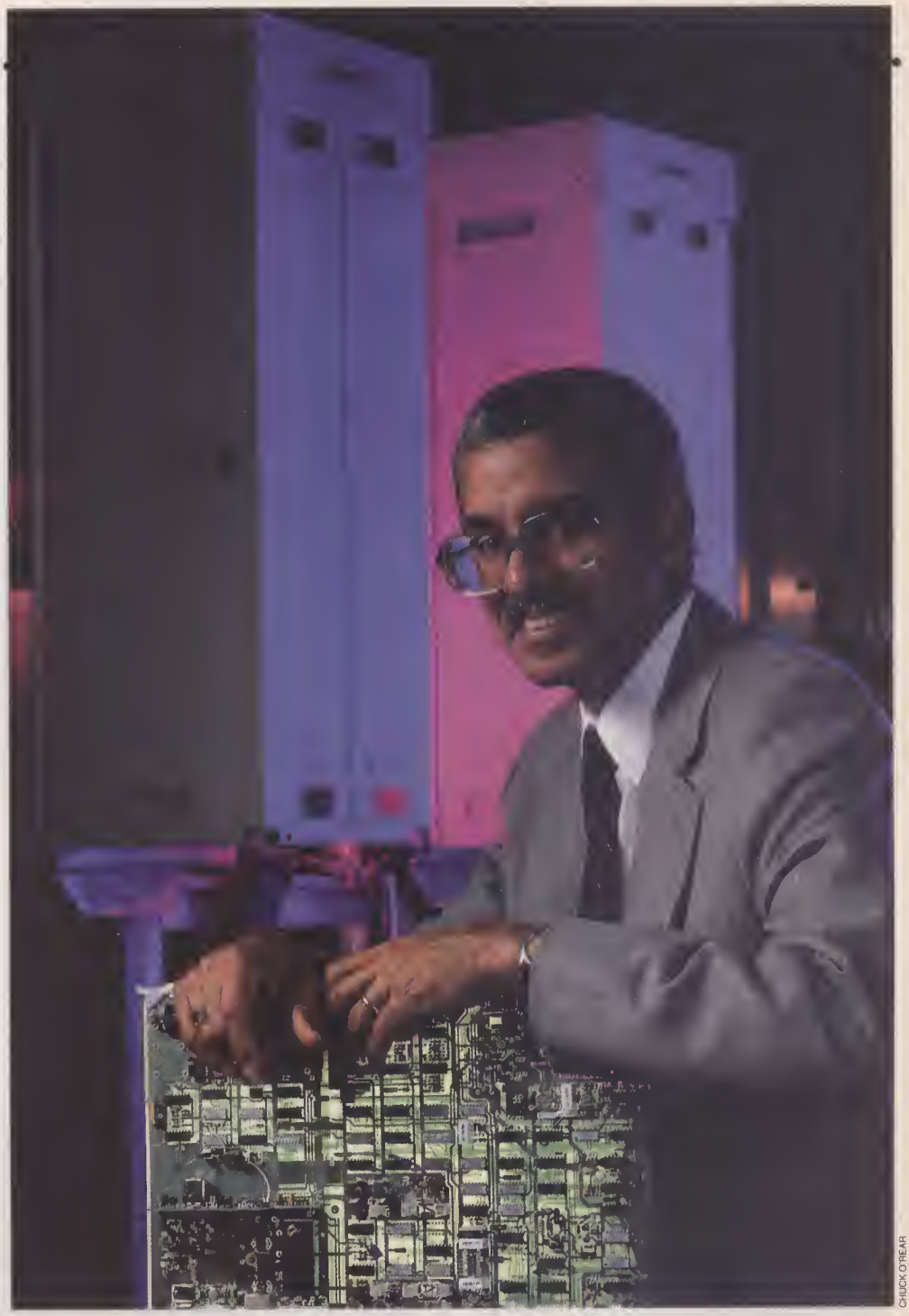
system of four satellites and 120 earth stations to supply private voice, data, facsimile, and teleconferencing capabilities to about 20 large, geographically dispersed organizations. Leased satellite channels have become increasingly popular for large corporate communications users because of the rapid decline in the cost and size of the earth stations needed to access these channels. And while most users needing private satellite links would never dream of launching their own orbiters, Electronic Data Systems (Dallas), which runs General Motors' new private communications network, has seriously considered building its own system based on three satellites (see "General Motors: the world's largest private network," p. 27).

As in so many other aspects of U.S. telecommunications, the future of bypass will be heavily affected by AT&T's attitude. Brian Moir, counsel to the International Communications Association, notes that the term bypass originally referred to the expectation that AT&T would build direct links to its best customers—not, as the term is now most often used, that these customers would themselves provide the links. As a bypasser, AT&T could become the local telephone companies' largest competitor. Last summer, in fact, AT&T beat New York Telephone for a contract to build a private network for state offices in Albany, a coup that industry experts estimate will cost NYNEX, the northeastern regional Bell company, $1 million in annual revenue. And AT&T already connects directly with the brokerage house of Merrill Lynch & Co. in Manhattan.



CHUCK O'REAR

Douglas Morais, general manager of Harris Corp.'s Farinon Division, demonstrates microwave systems designed for business users who need their own bypass links.

Recently, the FCC approved three AT&T services—Megacom, Megacom 800, and the Software Defined Network—that are seen by most industry observers as promoting bypass. Megacom is an outgoing service similar in concept to AT&T's usage-based WATS (Wide Area Telephone System) long-distance service. Megacom 800, as its name suggests, is similar to the existing "800" toll-free service. What the two Megacom services have in common is that they are accessed through private lines that may be provided by the local telephone company, by some other carrier, by the user, or by AT&T itself. Both services began in November 1985, much to the chagrin of the local telephone companies, who say that these services will drain about 20% of the WATS and 800 traffic from the public network. But the FCC rejected local phone companies' arguments that AT&T supplied the commission with insufficient data, although it will continue to monitor Megacom's progress.

AT&T also announced the availability of its Software Defined Network (SDN) in November. This new service allows customers to expand their private-line systems by remotely programming an AT&T switch for the kinds of transmission they require—data, video or voice, WATS, and so on. A competitor is U.S.

Local bypass stimulates microwave sales

Microwave systems are now the predominant means that businesses use to bypass the networks operated by local telephone companies. Such equipment has traditionally been used by AT&T and other common carriers for long-distance transmissions, and by utilities and oil companies for internal communications. But a significant part of the long-distance market will be taken over by fiber optic cable, according to Jean-François Grenon, VP of M/A-COM (Burlington, Mass.), a manufacturer of communications equipment.

"The real microwave boom," says Grenon, "is in local applications," which include intracorporate voice and data transmissions within an urban area and transmissions between companies and access facilities of long-distance carriers. Grenon estimates 1986 revenues of $70 million for this segment, which constitutes about a quarter of the total U.S. market for microwave systems. Within five years, short-haul equipment should make up over half the microwave market and account for $350 million in revenues.

Local microwave systems generally transmit within a range of 30 miles; purchase and installation costs are about $25,000–$30,000. Equipment is available from such companies as M/A-COM, Harris's Farinon Division (San Carlos, Cal.), Avantek (Milpitas, Cal.), Ericsson (Garden Grove, Cal.), GTE (Stamford, Conn.), NEC America (Fairfax, Va.), and Spectrum Digital (Herndon, Va.). GE's Gemlink microwave product was recently purchased by Motorola (Schaumburg, Ill.), and AT&T Information Systems (Morristown, N.J.) plans to sell equipment made by Digital Microwave (Santa Clara, Cal.). In addition to selling components, most microwave vendors will also set up turnkey systems.

Microwave is not the only means available for going around the local public telephone network (other options are fiber optic cables and dedicated T1 circuits leased from the phone company), but it has become the method of choice. "A private fiber optic network offers very large, secure transmission capacity," says Abid Butt, director of consulting services at TeleStrategies (McLean, Va.). "But few companies need this capacity, and the cost of acquiring the necessary right-of-way and burying the cables can be high, particularly in central business districts."

"Establishing a microwave communications path can be done much more quickly than with hard wire or fiber cable; with just two end points, you're in business. Microwave equipment is also easy to move if the firm changes offices or a new building blocks transmission."

Jorgen Bistrup
VP, Product Management
Farinon Div., Harris

"Microwave currently carries more voice than data traffic. But data transmission is growing faster as companies increasingly interconnect personal computers and mainframes in multibuilding networks."

Abid Butt
Director of Consulting Services
TeleStrategies

Leased lines provide the same kind of high-speed data transmission as microwave. "But installing microwave equipment is a one-time capital investment," says Victor Krueger, VP of telecommunications at Dataquest (Cupertino, Cal.), a market research firm. "Microwave costs are known and relatively stable, compared to prospects for continually rising private-line rates." By eliminating private-line payments and, in certain instances, access charges, a microwave system can generally pay for itself within two years, says Krueger. Another advantage of microwave over T1 circuits is that the circuits can take many months to install, and are not available everywhere.

Owning its own network is not the only choice open to a company wanting to bypass. Several digital termination service (DTS) firms, such as Local Area Telecommunications (New York) and Dama Telecommunications (Parsippany, N.J.), provide businesses with leased microwave facilities for intracorporate communications. This is still a nascent market, intended primarily for end users that do not generate enough communications traffic to justify setting up a private network.

Meanwhile, phone companies are responding to the bypass challenge in a number of ways. They are seeking permission from state regulatory commissions to offer bulk discounts for the installation of multiple private lines (fixed prices are now the norm). They are installing fiber networks—designed to serve private customers—along existing rights-of-way. And ultimately, they may offer a full range of cost-effective, high-speed communication services made possible by digital networks, which might eliminate the need for bypass. "The extent to which these strategies will be successful is the major question facing microwave suppliers," says Krueger.

—Dennis Livingston

ED KASHI

General Motors: the world's largest private network

In keeping with the size and geographic distribution of its operations, General Motors is developing the world's largest private telecommunications network. When completed in 1987, it will use a variety of technologies—satellites, microwave, and, most likely, fiber optics—to connect 250,000 telephones and replace 30 separate private data networks. The new network will replace GM's old private voice network, which was based both on its own interlinked PBXs and on central office switching facilities shared with AT&T.

In fact, the GM network will look rather like the old Bell System in miniature. There will be a multilevel system built around more than 600 PBXs: The lowest level—level 3—will consist of about 500 PBXs from Northern Telecom, Rolm, and AT&T, installed at GM offices around the country. Level 2 switches, in addition to supplying a local PBX function, will have a least-cost call-routing feature. At the highest level, nine central office switches will route long-distance calls through the network as well as supply some local switching functions.

GM started planning its new communications network in 1982. When the company took over Electronic Data Systems (EDS), the Dallas-based software and services firm, in 1984, responsibility for the network was shifted to EDS's Communications Services Division.

General Motors intends to install its own transmission facilities. In Michigan, Ohio, and Indiana, where there are many GM offices, private microwave links will be used; by the end of 1986, GM expects to have 5000 miles of such links in place. What's more, the high-capacity circuits that will link the central office switches in the GM network may use the company's own microwave or fiber optics facilities. GM or EDS may even put up its own satellites for long-distance transmission. However, "any plans for satellite transmission would be discussed with another recently purchased General Motors subsidiary, Hughes Communications," says Charles B. Jiggetts, director of marketing and public relations at EDS Communications Services Division. Fiber optic transmission facilities might be leased from a national carrier if that carrier's trunks were sufficiently close to GM's offices.

Once the network is in place, GM may offer bypass facilities to other companies. However, resale of GM's communications capacity is currently just a "possibility," says Jiggetts; the company does not want to find itself being regulated as a common carrier. In any case, the GM network will eventually connect the company's own offices with about 35,000 dealers, distributors, and suppliers, rivaling some independent carriers in size.

While all this may sound like bad news for both AT&T and the local telephone companies who presently handle GM traffic, they will actually all continue to get some business. For example, AT&T is supplying some of the switching gear, and Michigan Bell is installing the largest switches in the network. In addition, much of the interlinking of switches will be done via lines leased from local phone companies. Even with the GM net fully in place, says Jiggetts, approximately 60% of the company's calls will be placed through the public telephone network.

Telecom's Virtual Private Network Service. Software-defined networks of this kind are expected to grow rapidly throughout the decade because they are highly flexible and involve no capital construction costs.

The FCC's approval in late 1985 of tariffs for Megacom and SDN caused something of a furor among the local telephone companies. Thomas E. Bolger, the chairman of Bell Atlantic (Philadelphia) was quoted in the trade press as saying that the FCC decision "legalized" bypass—even though bypass itself is not illegal—and the U.S. Telephone Association, a trade group representing most of the local telephone companies, accused the FCC of approving services that would eventually cause a rate increase for residential customers.

Meanwhile, investor fears that the new services could hurt telephone company revenues and profits pushed down the stock prices of the Bell regional holding companies. But in approving the new services, the FCC commissioners argued that any revenue the local companies lost as a result of the Megacom services would be outweighed by an increase in other revenue, especially from leased lines. And they maintained that SDN would mainly attract customers already using private-line services.

Despite such assurances, local phone companies are responding vigorously to what they see as the SDN threat. New York Telephone, for example, has asked the FCC for lower tariffs for providing end-user access to the long-distance carriers' software-defined networks. The resulting lower access charges would enable New York Telephone to compete with private bypass to SDN. All the local Bell companies are now committed to providing extensive digital services based on fiber optics, with the eventual goal of providing an Integrated Services Digital Network (ISDN) that will provide users with access to high-speed data communications channels with the plug-in ease now available for conventional voice channels. The arrival of ISDN may indeed kill the demand for bypass, but the timetable for the widespread introduction of the network is hazy: the consensus seems to be the mid-1990s.

Dataquest's Krueger foresees that, as the alternatives to the local phone company grow, regulatory authorities will become concerned enough about the viability of the companies they regulate to open the way to more flexible pricing. If this happens, the phone companies will be able to adjust to the bypass competition and will not suffer greatly in the long run. However, if state regulatory authorities are slow to comply, the local phone companies could lose major customers that would be hard to regain.

Long-distance bypass, in contrast, is much less a threat to AT&T and the other long-haul carriers, since few large corporations can afford to set up their own multipoint long-distance microwave or satellite networks. And even the few companies with such facilities will remain heavy users of the public switched networks. In addition, AT&T's Megacom and SDN services are designed to compete with both private bypass and shared bypass services.

Thus, the main bypass battle is for the local-loop customers, and the main combatants are the local phone companies and the shared-bypass providers. How well the phone companies stand their ground will depend on how fast they can respond—and how fast they are allowed to respond. □

Lawrence Gasman is president of Communications Industry Researchers, a market research firm in Washington, D.C. He writes frequently on telecommunications issues and technology.

For further information see **RESOURCES**, *p. 69.*

TELEPORTS: AT THE CROSSROADS

Regional hubs for voice and data traffic show promise but have a long way to go

Teleports, like seaports, are places where traffic is concentrated, sorted, and dispatched to other points. But instead of ships and cargo, teleports manage voice communications, data files, and video signals. In most cases privately owned, teleports deliver local, long-distance, and international service, complementing traditional public carriers or bypassing them altogether.

According to the American Teleport Association (ATA), there are 22 teleports now operating in the U.S.; another 20 are under construction. When all are completed, says Robert Schmidt, president of the ATA, the total industry investment will fall between $600 million and $700 million, not including the substantial value of real estate developments with which several teleports are associated.

Teleports are often characterized as "antenna farms," because the first installations were concentrating points for satellite communications and so had several satellite dish antennas. Now teleports offer a variety of additional services. For example, the Washington, D.C., teleport, run by Schmidt, not only has 13 satellite dish antennas but also operates a local-access network and gateway facilities to long-haul carriers. Some teleports provide their customers with access to international services, either as licensed providers of Intelsat's International Business Service or through agreements with AT&T and Comsat (the communications satellite consortium). With Intelsat providing the international carriage capacity, teleports can form arrangements with foreign common carriers. British Telecom International and Mercury Communications, the United Kingdom's competing carriers, are the most common partners of U.S. teleports, offering customers access to the U.K.'s public telephone network.

Most teleports market their facilities to large corporate customers in metropolitan areas where land for satellite and microwave antennas is limited and expensive. The teleports usually build their satellite antennas away from densely populated downtown areas and run high-capacity microwave or fiber optic links from customers in the city center to the earth station complex. But because teleports provide shared capacity, even relatively small companies may find their services attractively priced.

A teleport's customers may also include other service providers, such as the local Bell operating companies (BOCs). BOCs are not allowed to provide service across their local-access and transport area (LATA) boundaries; they must use an inter-LATA carrier such as AT&T or one of its competitors. But a teleport can provide a BOC with inter-LATA and even international capacity. A BOC arrangement with a teleport has an added advantage: The phone company's customers enjoy the kind of one-stop shopping they were used to before divestiture.

Despite the apparent economic advantages they provide—shared services without the need for massive capital

by H. Paris Burstyn

JERRY JONES

Houston International Teleport president David Olson supervises the control room, where satellite communications are relayed to customers by microwave, fiber optic cable, and conventional telephone lines.

investment in facilities—teleports have not been a runaway success. Several teleports that were seriously planned have failed to materialize, largely because of problems in raising capital for expensive ground facilities and networks. Of three teleports that had been planned in Texas, for example, one failed and another (in the Dallas–Fort Worth area) now provides only video services; the third, in Houston, has finally become operational. Even in New York City, where telecommunications demands are exceptionally high, the New York Teleport on Staten Island ran into repeated delays before it began operation last year. But "the teleport business may be at a threshold now," says David Rubin, a telecommunications analyst at Arthur D. Little (Cambridge, Mass.). "Given solid financial backing, conservative business plans, and locations close to a business community that can provide sufficient traf-

ROBERT SCHINELLA

Arrays of satellite dishes (for long-distance communications) and microwave towers (for local links) characterize teleports in New York, Chicago, and the Washington, D.C., area (run by Communications Technology Management). In San Francisco's Bay Area Teleport, the network control center (shown) uses microwave to tie into its earth station nine miles away.

fic, many of the teleports will succeed."

At this stage, teleports are of two basic types: joint ventures with major real estate developments, and pure communications centers. In the former case, an office park can be wired directly to the teleport, which need not be on the same site.

New York's joint venture. The New York Teleport, which began service last year, is a combined telecommunications and real estate venture occupying a 220-acre site on Staten Island. The founding partners are the City of New York, the Port Authority of New York and New Jersey, Merrill Lynch, and Western Union. New York City will spend approximately $15 million to build roads and provide basic services. The Port Authority, which plans to spend about $57 million on the project's real estate development, has subleased a 21-acre parcel to Teleport Communications, the Merrill Lynch/Western Union joint venture that oversees the communications aspects of the project. Robert Annunziata, president of Teleport Communications, says the entire project, including the real estate development, will cost about $225 million. So far, about $25 million has been spent on telecommunications facilities.

The New York Teleport is already attracting a significant level of traffic. Since June 1985, Comsat and TRT Communications (an international telex carrier) have operated earth stations at the teleport. Among the major teleport users are the Catholic Telecommunications Network of America (with four hours of traffic a day) and a private satellite network that handles direct broadcast operations for large organizations such as Merrill Lynch, J. C. Penney, Ford, and the U.S. Army.

During 1985, Teleport Communications completed a 150-mile fiber optic network that runs through Princeton, North Brunswick, Jersey City, and Newark in New Jersey, and Manhattan, Queens, Brooklyn, and Staten Island in New York. According to Annunziata, this network—which allows Teleport Communications to bypass New York Telephone—now has 20 customers: Bankers Trust uses it for point-to-point communications between offices in Jersey City and Manhattan, and other companies use it for direct access to long-distance and international services. What's more, he says that the teleport welcomes traffic from local phone companies. Already, New Jersey Bell is among its customers.

Houston's telecom center. The strategy at the Houston International Teleport (HIT) is almost the exact opposite of New York's. HIT's antennas are on the outskirts of Houston, where they do not require the extensive shielding needed on heavily developed Staten Island. The teleport does not bypass the local telephone operating company, its partners are all private firms, and it is not affiliated with any real estate venture. HIT president David Olson created the teleport in conjunction with two of his associated firms that provide portable satellite uplink/downlink capacity for broadcasters and encryption services for secure transmissions.

Olson says HIT chose its site to be

completely frequency-coordinated from horizon to horizon—that is, its international and domestic earth stations can be turned to see any satellite without worrying about interfering with other common carriers. The facility can accommodate up to 30 fixed earth stations and is accessible by microwave and fiber optics from points throughout the region.

The downtown hub of HIT's telecommunications links is atop the Allied Bank Building, the second tallest skyscraper in Houston. On this tower are microwave antennas through which HIT connects with its customers. Similar microwave links relay communications to HIT from the Johnson Space Center and AT&T's long-distance switching center via the Allied Building. Southwestern Bell (the local operating company) also sends traffic via the Allied Building to HIT for access to long-distance carriers; Southwestern Bell will eventually provide a fiber optic link to replace the microwave. LDX, a regional fiber optic network operator, uses HIT to provide its clients with links overseas. And HIT has a number of routes to Europe via Intelsat, British Telecom International, and Mercury Communications.

The company's client base is also being expanded with help from its affiliate, Satellite Transmission and Reception Specialists (STARS), whose main business is the operation of a fleet of transportable earth stations. Once deployed, these stations use HIT as a downlink. For example, shortly after last fall's earthquakes in Mexico City, ABC News began setting up satellite communications for its broadcasts, but no satellite uplink facilities existed in Mexico's capital city. The network hired STARS to arrange for a transportable uplink truck to be flown to Mexico City. "Once we left Houston," says Olson, "it took 13 hours to be up and operational."

Which business strategy—joint venture or pure communications center—will pay off best in the long run remains to be seen. In fact, industry observers believe that the jury is still out on whether the teleport concept itself will succeed. Teleports that have set up shop and begun to carry traffic have all incurred capital expenditures ranging from about $50 million to over $200 million, depending on the extent of the communications facilities and on whether a real estate development was involved. While these teleports have attracted customers and enjoy continuous revenue streams, their profitability is not yet known. Most of them are either privately held firms that have not released figures on profits, or joint ventures of larger concerns that do not break out performance data on their subsidiaries. As with any new technological concept, teleports offer bright prospects for rapid future growth. But the growth curve often starts slowly, and teleports face a long period of customer education. □

H. Paris Burstyn is an analyst with the World Telecommunications Information Program at Arthur D. Little (Cambridge, Mass.).

For further information see **RESOURCES**, *p. 69.*

THE WORLD ACCORDING TO USERS: A PANEL DISCUSSION

Five industry experts look at the big issues for business

To learn how businesspeople are dealing with the fast-changing telecommunications scene—and to get their viewpoints on the industry's major trends—HIGH TECHNOLOGY assembled a panel of three distinguished telecom managers and two leading consultants. In the broad-ranging discussion that ensued, they displayed surprising consensus on what technologies hold the most potential and on the likely evolution of the industry.

For example, the panelists confirm that the trend toward bypassing the public phone companies springs not only from businesses' need to reduce costs but from their desire to control their own networks. And the form of this bypass has as much to do with the physical nature of the route as with the pluses and minuses of competing technologies. Despite the heavy promotion of products that integrate voice and data, the managers have yet to feel an overwhelming need to combine the two (although the spread of electronic mail could eventually change this). And the great LAN-versus-PBX debate seems to be less an issue than some might believe from listening to vendors that promote one side or the other; the panelists see room for both technologies in their operations.

The panel expresses considerable interest in the much heralded Integrated Services Digital Network (ISDN). All expect ISDN to play an important role in their future operations, but the critical word is *future*. Most are skeptical about current product claims of "ISDN compatibility," noting that the concept still has to be standardized before it can achieve much market impact.

The importance of network management, and the difficulty of achieving it, were major themes in the discussion. In today's environment of diverse products, services, and networks, establishing an overview of a company's communications activity can be an overwhelming task. The panelists discuss how they try to manage this situation, and point out that standards are needed to make total network control more attainable.

PANELISTS

Telecommunications managers:

Stephen F. Kelley
Director of Corporate Consulting and Telecommunications
John Hancock Mutual Life Insurance Co.
Boston

John Doggett
Vice-President of Telecommunications
Bank of Boston
Boston

Wayne A. Hall
Manager of U.S. Telecommunications
Digital Equipment Corp.
Maynard, Mass.

Consultants:

Stan Badowski
Vice-President
DP Communications
Great Neck, N.Y.

James G. Herman
Director, Telecommunications Consulting Group
BBN Communications
Cambridge, Mass.

HT: *Historically, companies have acquired their communications and computing equipment piecemeal, and incompatibility problems have often resulted. Do your organizations have a central point of control in order to avoid such problems?*

HALL: In Digital's case, it's a mixed bag. Strategic direction for the most part is from the top down, and large purchases generally have to be run all the way up the chain in order to get approved. Within that framework, though, we give our site telecommunications managers throughout the world a fair amount of local autonomy. Of course, at Digital we're somewhat limited in the number of vendors that we work with.

DOGGETT: It's somewhat similar at the Bank of Boston. Historically, we've had a very centralized organization. It's only in the past year that management has actively pursued a decentralized approach, with autonomous business units and so forth. They've retained a centralized group for strategic direction in telecommunications, but for acquisitions, local autonomy is the order of the day. My group basically works in a consulting mode with individual managers. We do have some sign-off rights, but my preference is not to exercise them. We work through negotiation and persuasion.

KELLEY: There seems to be a consensus among telecommunications managers to serve as internal consultants; we're doing very much the same thing at John Hancock, especially with outside subsidiaries. They don't have to take our advice—they can pretty much go out and buy what they want—but our intent is to make sure that what is acquired fits within some sort of standard.

HT: *Do you find you have any difficulty in educating senior management about the technological problems in telecom and the need for standards?*

KELLEY: Yes, it's a problem, because senior management usually isn't technical. Management still perceives telecommunications as very much telephone-related. If they can make a telephone call, they assume things are going well. This is often a hindrance in getting them to spend money on advanced technology.

PHOTOGRAPHS BY LOU JONES

Participants in the panel discussion were (clockwise from top) Jeffrey Bairstow (HIGH TECHNOLOGY), James G. Herman (BBN Communications), Wayne A. Hall (Digital Equipment), Robert C. Haavind (HIGH TECHNOLOGY), Dwight B. Davis (HIGH TECHNOLOGY), Stephen F. Kelley (John Hancock), John Doggett (Bank of Boston), and Stan Badowski (DP Communications).

BADOWSKI: As consultants, we get involved with all types of organizations—bureaucratic, entrepreneurial, any conceivable mixture—and we see all kinds of management. Sometimes we find that senior management is not technically oriented and does not care to be. But other times, we've found that the president of the corporation knows bits and bytes and C-language programming and he puts our staff through the wringer. We've generally found that the more entrepreneurial an organization, the more likely that senior management knows technology.

Telecom personnel

HT: *Is it a problem finding technologically qualified people?*

HERMAN: It's very difficult at the moment, especially in an extremely complicated, fast-moving field like data communications.

BADOWSKI: That's why the consulting business is doing fantastically well right now. Organizations may have the bucks to spend to hire the people, but they can't find them. That's when we get called in.

DOGGETT: My policy, in fact, is to keep a lean and mean staff of senior individuals at the bank who can work with outside consultants. Because of the number of fields we get into in the telecommunications business—microwave, fiber optics, satellites, and so on—we cannot staff up gurus all over the lot. Besides, such a staff would be too inflexible to keep pace with the fast-moving market. So consultants form a central part of our staffing policy, allowing us to pick a fresh group every time we tackle a new problem.

HALL: That would be a problem for Digital, because our internal communications environment is somewhat different from the typical large corporation. It is quite difficult for us to find people who are very familiar with DECNET [Digital's computer networking protocols], for example, or with the kind of communication environment we have within the company. So we have to devote a great deal of effort to developing training programs and growing our own staff.

DOGGETT: We find a personnel squeeze not only in designing integrated, high-powered networks, but in their day-to-day operations as well. AT&T still has a virtual monopoly on that kind of talent. And that's where problems become most obvious to our senior management. It's not the difficulties with fiber or microwave that they worry about, but whether they've got dial tones today.

KELLEY: I find that the personnel shortage exists across the board. Both in high-level technical people and in operations people, and even in administrative support. We need at least two or three additional people just to handle the volume of bills from the multitude of different vendors and phone companies.

BADOWSKI: One staffing problem involves large companies that spend a lot of money to bring in and train technicians to run equipment. Because a company's personnel policy won't permit giving them a $5000 or a $10,000 raise, the technicians just move on to another company that can offer that type of raise and the opportunity to move up the organizational ladder. One California company that was experiencing this problem created a new employee category, "consultant," in order to reclassify these people. Because it was essentially a management-level classification, the company was able to offer sizable raises and bonuses to valued telecom personnel in order to retain them.

Integrating voice and data

HT: *We understand that John Hancock is planning to replace its Centrex phone system, provided by the local telephone company. Why?*

KELLEY: First of all, It's lacking in features. And what it does offer is on a pay-per-feature basis, which gets very expensive. In general, we've found the system to be extremely inflexible in terms of what we need for our business.

We've been testing a digital PBX on a 24-month basis to determine what our needs are for digital communication. Just how much integrated voice and data do we need? What kind of demand is there for integrated video display terminals? How much communication with the main computer do we need? What kind of modem pooling [sharing] will be cost-effective for us? We're learning a lot from that right now. Much of what we learn is going to go into a request for proposals. We fully expect that one of the responses will be from the local phone company proposing an enhanced Centrex. We'll just have to wait and see what they propose; we're not necessarily closed to the concept of enhanced Centrex, we're just not particularly happy with the present one.

HT: *How many lines are you talking about within your company?*

KELLEY: This particular switch would probably be on the order of 6000, with a required capability of 10,000 up front— because we're not sure of the display terminal population that would be on it—and a capability to grow up to 20,000 or 30,000 eventually.

HT: *What kind of data speed would you want to use for transmitting digital information on your PBX?*

KELLEY: That's something we're grappling with right now, relative to the differences between PBXs and local-area networks. It appears that for any really high-bandwidth applications—if you get into bit-mapped color displays, for instance—data should probably be carried on alternate facilities. Casual users, those who use electronic messaging or voice messaging, probably don't need more that 64 kilobits per second initially. Certainly, that would be the minimum requirement. But we would expect to aggregate those lower-speed PBX bandwidths into T1s [high-speed communications links that carry voice and data at 1.544 megabits per second] for external connections.

HT: *Is anyone else using a digital PBX at this point to transmit internal data traffic as well as voice?*

HALL: Digital is, but only to a limited degree. Over the past five or six years, we've made a substantial investment in separate data PBXs [central switches designed to route data traffic]. They work fine, and because they're not broken we tend not to want to fix them. The other, perhaps more important, reason for our limited use of voice PBXs for data is that with our Ethernet local-area networking products we have another alternative for transmitting data.

DOGGETT: Even though the low volume of data we transmit is growing fast, the number of data terminals in the head office is still relatively small compared to the number of voice terminals. Thus the incentive to integrate everything is not yet there. The watershed for the Bank of Boston will be electronic mail. We're a conservative organization, and we haven't yet explored electronic mail the way we should, but I believe it's going to propel us into an integrated voice/data environment very rapidly. The telephone system works fine technically, but it's breaking down on the human side. Most of us have experienced telephone tag, with a stack of slips on the desk a mile high. Electronic mail will be adopted just to alleviate that problem, and with such a force in place we'll be pushed into coherent planning for voice/data integration.

HT: *Couldn't some of that messaging be handled by voice store-and-forward systems?*

DOGGETT: Yes, and we are actually pursuing that more actively than electronic mail right now because we feel it's a more friendly technology. But on my desk right now, I find I need both.

KELLEY: Hancock has multiple messaging systems, both electronic mail and voice messaging. A key consideration is to have a single point of access to these multiple systems. That's where the PBX might come in, tying together these multiple directories [which list the messaging system used by each addressee and tell what format to use]. We're also experimenting with digital PBXs to provide integrated video display terminals with a single message indication to tell you what system a message comes from.

DOGGETT: I think the directory is a key issue. Because of the bank's policy of doing whatever you like within our corporate guidelines, we now have 13 electronic mail systems and two voice mail systems. As a result, we've asked our data group to come up with a corporate directory. And as these directories begin to stack up, what is now just a problem for individual companies is going to be a problem for the nation. If I want to communicate with Wayne Hall, for example, I need to get into his corporate directory. First we've got to have a physical gateway,

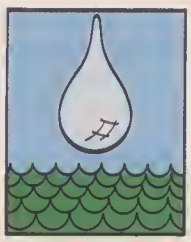
"Among the people I've talked to, very few are using PBXs for data. They're almost all putting in LANs as fast as they possibly can."
—HERMAN (BBN Communications)

"What is ISDN? It's like waiting for Godot. It's coming, so you don't change now. You just wait."
—BADOWSKI (DP Communications)


PEELING THE LASER BEAM DOWN TO ITS CORE.

AT&T Bell Laboratories scientists have generated a beam from a diode laser with a frequency spectrum 1,000,000 times narrower than that of today's most advanced commercial semiconductor lasers.

Part of a record-breaking coherent lightwave system, this laser 'peels away' a tremendous number of unwanted frequencies that can clutter up a beam—to create a lightwave so pure, its frequency variance is limited to 1 part in 40 billion. The equivalent of one drop of ink in a million-gallon, Olympic-size swimming pool.



A drop in 40,000,000,000

Purity Has Its Rewards

The new narrow-spectrum laser is the key element in a coherent lightwave communications system that increases the information-carrying capacity of an optical fiber, as well as the distance over which an unboosted laser beam can be received.

Increased capacity comes from dramatically increasing the number of individual laser beams that can be sent through a fiber's best transmission window.

Each laser in a coherent system produces an exceptionally stable, pure wavelength—allowing thousands of non-interfering wavelengths to travel side-by-side on a fiber. (Only a handful of beams can be combined using today's commercial semiconductor lasers.)

Dial 'M' For Movie

In the future, the capacity of coherent transmission could allow us to send 10 million conversations—or 10 thousand digital TV channels—simultaneously, on a single fiber.

Or, using the full capacity of a fiber, a coherent system could dump a movie like 'Gone with the Wind' into a home memory unit in one second flat. Or deliver Beethoven's '5th' in less than a 50th of a second.

Making A Little Go A Longer Way

Increasing capacity is important in an age of rapidly expanding information needs. But so is reducing costs—in this case, by nearly doubling the distance an unboosted signal can be received.

A newly developed AT&T coherent lightwave receiver contains its own narrow-spectrum laser. The beam from this laser reinforces the transmitted signal as it detects it—a technique only possible with two such pure beams.

Using this receiver, AT&T has achieved a laboratory transmission record of nearly 100 miles at a data rate of 1 billion pulses per second.

We Don't Keep The Future Waiting

Coherent lightwave transmission is just one of the ways AT&T is working toward the high-capacity, high-speed integrated networks of the future.

Meanwhile, we're bringing tomorrow closer with leading-edge lightwave systems we're building today.

AT&T this year introduced a commercial lightwave system—the FT Series G—designed to operate at up to 1.7 billion bits per second, a rate that permits the transmission of 24 thousand simultaneous calls on a single pair of fibers.

And by 1988, we'll have installed the first transatlantic and transpacific lightwave systems to Europe and the Far East—systems capable of transmitting 40 thousand simultaneous conversations on two pairs of fibers.

Clearly, whether on land or underseas, AT&T is lighting the way in lightwave. And peeling the laser beam is part of it.

AT&T

The right choice.

of course, but I also need to know how to access his network and mailbox.

HT: *What is the status of gateways that form links between the various types of electronic mail systems?*

HERMAN: Mail gateways are not difficult to build, and they will become very common in a few years as standards evolve. There are two competing standards for electronic messaging, one in the SNA world [IBM's networking architecture and protocols] and one in the international standards world. It looks like we'll be blessed with only these two standards, as opposed to dozens of standards in areas such as local-area networking. That will make the ability to gateway across networking boundaries in order to exchange electronic mail quite simple a few years from now.

HALL: But in the proliferation of those kinds of gateways there are some security problems that worry a lot of companies.

HERMAN: Yes, people first work very hard to give access to networks, and then they work on closing down the access.

HT: *Is there a way to achieve a happy medium between open access and security needs?*

HERMAN: BBN does a lot of work for the Department of Defense, so we're very security conscious. But we find that DOD is not very worried about electronic mail gateways; it's relatively open to the possibility of letting people exchange mail freely between different systems—many of them with widely different security constraints—because that type of exchange doesn't give people log-in access to the computer systems as users. If you send a mail message to a particular organization, the mail program will deposit it in the proper mailbox without giving you access to the organization's computer system.

BADOWSKI: Still, there is a problem with the public *perception* of a computer's security. All you usually need for someone to dial in is an ID and a password. Often when you dial in you immediately get a message back saying something like "Welcome to XYZ's bank system." If that message is published in the newspaper—as happened in the case of one *Wall Street Journal* article—the word goes out that people can get into the bank's computer. Even though it's only an electronic mail system, the public response is "Oh, can someone take my money away?"

LAN versus PBX

HT: *How's the LAN-versus-PBX competition shaping up? Will so-called fourth-generation PBXs succeed in their attempt to carry more and more data traffic, and thereby displace LANs?*

HERMAN: Among the people I've been talking to recently, very few are using PBXs for data. They're almost all putting in LANs as fast as they possibly can—all kinds of LANs, sometimes dozens of different ones in a single organization. It's a whole new world of incompatibility.

This is happening in part because of the voice/data split in people's backgrounds. Those who primarily work with data systems seem to be more comfortable with the LAN technology; they see its potential functionality—shared disk memory and true distributed processing, for example—as something they might want someday. When you get a PBX, on the other hand, you essentially get a wire that hooks you up somewhere. It's a fancy wire, but still a wire.

DOGGETT: I think that's rapidly changing. We've just installed a Northern Telecom DV/1 to test this kind of fourth-generation PBX and find out what it can do. The advertising says it delivers 2.56 megabits to the phone. That's pretty powerful. The question is, what do you do with it? Is it a LAN? Is it a telephone system? Is it a shared PC environment? What is this box?

AT&T—and no doubt Rolm, with it's IBM connection—will also be coming out with products in the same vein. But will the technology be compatible with lots of different equipment, whether it's DEC, IBM, Wang, or whatever? If you're going to have a departmental system, this is not an issue. You can choose your Corvus or 3Com LAN or what have you. But when you get into a corporate-wide or institutional situation, you have to have a system that's going to accommodate a wide range of currently available technology. That's the tough one.

Meanwhile, in *our* environment—and maybe we're unusual—we do not have much demand yet to share data. The need to communicate with the mainframe, where most of the data reside, is greater, but not much. For most people, the *P* in the PC—*P* for personal—is the powerful aspect. I've got my processor on my desk, I've got it for whatever I do, and I don't really want to have to talk to anybody else. With one exception: I might like to link to a laser printer to really pump out some fancy copy.

In fact, there's almost a resistance to LANs. As soon as I go to a shared hard-disk environment, somebody else is running it; I'm losing control. And if that disk goes down, all the central DP shop issues that you have just gotten away from with the PC reappear. Maybe that's life, but it's because of that resistance that we haven't had any great penetration of LANs.

HT: *Doesn't that contradict the usual argument that the proliferation of PCs is driving the need for LANs?*

DOGGETT: There are two thrusts here. It is the individual contributor—the professional—who holds to that stand-alone notion. But in terms of the corporation, there is a requirement for hooking PCs up to mainframes and minis. We're all doing our budgets on the PCs, for example, and they have to converge on a central site and get distributed. The individual led the trend to introduce PCs into the organization, for individualistic reasons. But now the organization, in trying to use these systems most effectively, is going to force the LAN issue.

HALL: Things are very different for Digital. We are heavily into LAN technology, with more than 150 Ethernet installations around the world. But it has not been the PC explosion that has driven that growth in LANs. It's been the need to efficiently connect minicomputers and larger computers by a mechanism that's much simpler and easier to manage than the old mesh type of connections. PCs came along later.

BADOWSKI: We find that LAN technology is taking off largely because of the needs of expanding organizations, many of which relocate some 30 to

40% of the staff to different facilities each year. If you have to pull in new cable into a relocated person's office each time—you're talking several thousand dollars a shot—that can really add up. But if that person can simply link into an internal wiring system, the cost of relocation is drastically cut.

KELLEY: The other big benefit will be in data protocol conversion, so that dissimilar devices can access a variety of different hosts.

HT: *Will this occur over the LAN or the PBX?*

KELLEY: I don't see them as dissimilar. I think a PBX is just one type of LAN, and you gateway it to other LANs just like you'll gateway Ethernet to IBM's token-ring LAN.

HT: *But to achieve that kind of connectivity between different devices will require a greater uniformity of standards. What's happening there?*

HERMAN: There is a lot of activity because of pressure from users. But the problem is that manufacturers each have particular end points in mind, which don't happen to be identical. So a lot of pushing and pulling is going on.

IBM's SNA is certainly the de facto standard. I was talking recently to a person at an engineering company that has a lot of different types of computers and was going completely with an IBM SNA solution. I asked him if having the closed architecture of SNA didn't concern him. He smiled and said, "We have an *open* architecture. Everyone offers SNA compatibility." And he really had little regard for X.25 [a packet-switching network standard] or the International Standards Organization.

Effects of divestiture

HT: *The breakup of the phone company caused a lot of confusion in the industry. But have we now reached a point at which the effects of divestiture are well enough understood that you can confidently map your telecommunications strategies?*

BADOWSKI: I don't think so. It's just over two years since divestiture occurred, and people are still confused.

"Senior management usually isn't technical. If they can make a telephone call, they assume things are going well."
—KELLEY (John Hancock)

"Consultants form a central part of our staffing policy, allowing us to pick a fresh group every time we tackle a new problem."
—DOGGETT (Bank of Boston)

For example, at DP Communications we get calls from small or medium-sized banks who are relocating and want to take that opportunity to put in a new PBX system. But as soon as the word hits the street, every vendor in creation is banging at their door, and they simply don't know how to sort out each one's advantages and disadvantages.

The restrictions placed on phone companies under divestiture have also caused problems. In one situation, NYNEX [a regional Bell operating company] submitted a proposal to a relocating bank to put in a GTE-only PBX system, which was supposed to be installed by New York Telephone [a local Bell operating company within the NYNEX region] and maintained by GTE. At that time, however, NYNEX and New York Telephone were not permitted to sit together at the conference table to discuss the installation. When the client sees this, he's not going to accept the plan, no matter how little it costs.

HERMAN: The activities of other companies now active in telecommunications are also difficult to track. It's hard to say, for example, what will happen with the IBM/MCI/SBS (Satellite Business Systems) alliance. Divestiture has also caused severe lead-time problems; it still takes up to 18 months to get a 56-kilobit circuit, which is more than twice as long as it took prior to divestiture.

KELLEY: That delay is across the board. Even for 9.6-kilobit analog circuits it's taking up to two months, when it used to be 20 or 21 working days.

HALL: One of the things that this means for companies like ours is that we have to do a lot more planning than we did in the past.

HERMAN: You practically get into an inventorying mode, where you have to acquire bandwidth on speculation just so you'll have it if you need it.

HALL: I agree. The name of the game for large users is putting bandwidth in the bank, by whatever means makes the most sense. That's certainly what we're doing at Digital.

HERMAN: This represents a tremendous change in thinking from just a couple of years ago, when people optimized their long-distance, 9.6-kilobit networks to get the absolutely perfect configuration. They didn't spend a penny more than they had to. But now, they talk about people getting large amounts of bandwidth—T1 bandwidth—so that they have it in the bank. As a result, the way you go about being an effective manager today is very different from the way it used to be. You have to make strategic choices. You have to decide whether to go and buy, for example, a nationwide satellite system or a T1 system, rather than being subject to the phone companies' unpredictable rates.

DOGGETT: I think that the major effect of divesture has been the transfer of power—the transfer of control—to the end user, whether they like it or not. It's a revolution. And it offers the potential for significant enhancements in efficiency and services.

For example, we still spend 82% of our budget on voice, and we're now able to use the economies of scale and buying power on the voice side to help leverage our data communications. When you bring in a T1 service you can realize such savings on voice that you can usually pay off the T1 quite handsomely. Then you can essentially run data over part of the T1's bandwidth for free.

HERMAN: Nevertheless, it's still hard to convince management that it's a good idea to spend money today on something for which there isn't yet a demonstrated need. If you can show them convincing growth curves, then they might understand that the outlay is a good one. But you're spending money on telecommunications in a way that's very different from the way you used to, and it's disconcerting.

HT: *If customers are confused by all this, is there a tendency to just stick with AT&T and the local phone companies?*

HERMAN: Not necessarily. I've met only one person, in fact, over the past two years who said that his company plans to stick with AT&T completely. For intra-city communications, people are buying microwave circuitry. There's also a lot of activity in satellites, particularly low-cost satellites, as a way of getting around the problems of long-distance circuits. In a traditional setup, you have to deal with two local phone companies and one long-distance carrier, and when the circuit is down, you get into a classic finger-pointing problem: Who's going to take responsibility for fixing the circuit? Increasingly, companies are deciding to deal with the problems themselves.

Bypass

HT: *As you note, customers can bypass both the local phone companies and the long-distance carriers. Are any of you using some sort of local bypass technology?*

KELLEY: We're going to implement T1 access to the AT&T point of presence [where the long-distance carriers' facilities connect with each of the 160 local-access and transport areas (LATAs) around the country]. But we'll be leasing the T1 lines from the local phone company rather than installing our own T1 links. The T1 lines offer just a marginal cost benefit above optimally configured lower-speed links, but they also offer us much greater flexibility.

DOGGETT: We have microwave links at the Bank of Boston. We've also got direct cable running to GTE's Sprint, and we too are looking at a direct link to AT&T's point of presence. There's a cost reason for bypassing, but there are also reliablity and operational reasons for doing so. I want to deal with my supplier directly, not through a third party. The more boxes you've got in a line, the more trouble you're going to have. So cutting out a 5ESS [a large routing switch often used at the local phone company's central office] is fine with me. Why not go directly to the toll office [point of presence]?

HT: *What factors do you consider in choosing the type of local service to use: microwave versus fiber link versus going with the local phone company T1 carrier? What trade-offs are involved in these decisions?*

BADOWSKI: There are inherent restrictions on each technology. For microwave, you've got to have line-of-sight between the stations. If you want to install fiber optics, how do you run your cable from point A to point B? If you're in New York, can you pull the cable through the subway system tunnels? It's not so much that one technology is better than the other, it's

just the physical constraints of connecting two points.

DOGGETT: Often it seems that there are a lot of options, but they may be limited by those constraints. For example, NYNEX will do an awful lot to provide you with private service: They will install your facility, and you could either lease it from them or buy it outright. Or you could do it entirely by yourself. But there aren't so many choices in a given situation. When we linked our data center to our head office, microwave was the only choice we had. We couldn't lay a cable over the three- or four-mile distance, because it would cost too much. We didn't want a local telephone company phone service, because tie lines just don't offer the kind of service we require. Microwave made sense.

Actually, though, my preference is copper cable. I have a problem with fiber and microwave because they're active systems. They require a lot of maintenance, and they require power. Because stability in power supplies is quite frequently our biggest problem, we have all kinds of generators and fancy emergency systems in our head office. But at the far end, that's not usually the case. And it takes two to tango. So we choose copper cable whenever possible, but that gets expensive on a distance basis.

HT: *Is the motivation to set up a private network primarily to reduce cost or to gain more control over your communications?*

HALL: It's both in Digital's case. Because our environment changes frequently—real estate plans are altered, people move, new applications come along—flexibility and the ability to react quickly to new requirements are probably at least as important as the economics.

KELLEY: The control also extends to correcting problems. When the circuit breaks, or when you have a high error rate, you know who to call to fix it.

HT: *Still, it would seem that if you set up private networks, you need more people in-house to run and maintain them. Given the shortage of talented personnel, how is this accomplished?*

HALL: It's partly a question of personnel, but it's also a question of tools. If

"We do not use satellites at all for voice. And as long as I have something to say about it, we probably never will."
—HALL (Digital Equipment)

"Bandwidth capacity is almost like a gas in physics. Your information tends to expand to fill a given volume."
—KELLEY (John Hancock)

you have the right tools—even if you have to develop them yourself—you can provide an equivalent level of service with a smaller number of people or an equal number of less well trained people.

DOGGETT: Because of that, a product's ease of use and self-diagnostic capability usually become significant criteria when evaluating it for purchase.

Satellite technology

HT: *The long-distance carriers are doing a lot of fiber installation. How will that affect your use of satellite communications?*

DOGGETT: I think it will have a significant impact. For example, the bank is interested in the Atlantic fiber route that is supposed to be installed between here and London by 1988. That's going to significantly lower prices and improve the lead time for circuit availability.

We've already taken out a lot of our satellite circuits because we found them unsatisfactory for both voice and data. Sometimes satellite is the only way to go. There is no terrestrial circuit to Argentina, for example. But by and large, we will tend to go for a land-based circuit because it provides higher quality—that is, it avoids the delay issue [the length of time it takes to send signals up to, and down from, satellites].

HERMAN: An engineer at BBN likes to say that delay is the entropy of communications. Once it's there, you can't get rid of it.

KELLEY: I've had a similar experience, and I'm also inclined to minimize satellite usage. If a vendor can guarantee terrestrial routing, that's a significant point in his favor.

HALL: We use satellites for video and data to a limited degree. We do not use them at all for voice. And as long as I have something to say about it, we probably never will.

DOGGETT: One area in satellite that we *are* cautiously looking at is VSAT [very-small-aperature terminal] technology.* For us, VSAT is the only way that we can see getting out of the private line business, with which we have many multidrop lines [circuits with a large number of nodes attached] from Maine down to New Jersey. We've got some problems with satellites, as I've said, but VSAT looks like a viable alternative. Also, it can be a two-way interactive operation, not just a broadcast.

HERMAN: There's a tremendous amount of VSAT activity both among users buying equipment and among vendors entering the market with new products. Everyone is getting into the game.

HT: *Is VSAT going to save satellites in the face of competition from fiber optics? Or will fiber become so pervasive that its economies will hurt even VSAT?*

BADOWSKI: There will be applications for both. A large organization with key offices in the major city hubs will probably go to fiber technology. But if it is the type of organization that has numerous branches—a retailer, for example—then it will probably be cost-effective to go with satellite.

KELLEY: Even in insurance, I can see applications that are so paper-intensive that it would probably be good to transmit images. When you get hundreds of thousands of claims per day, some of which may be handwritten or in nonstandard fonts, frequently you want to use the image because you don't want to rekey the data. If you have lots of remote claim-approval sites, then it may make a lot of sense to put in a VSAT-type application, which has enough bandwidth to support the image traffic.

HERMAN: With VSAT in the future, you should be able to easily get a couple of hundred kilobits to end points where today you get 9.6-kilobit-per-second multidrop. It's a tremendous difference in scale. Meanwhile, fiber optics will drive the availability of T1 and faster links between major hubs.

HT: *Do any of you anticipate that the installation of fiber is going to provide so much capacity that your communications costs will drop significantly over the next few years?*

KELLEY: It's really hard to say. Bandwidth capacity is almost like a gas in physics. Your information tends to expand to fill a given volume. Five years ago, everybody thought 9.6-kbps circuits were as fast as you were going to need for most of your general business applications. But at this point, those are just medium-speed, almost low-speed, circuits. So even though the cost for capacity may drop, we'll probably be transmitting more information. The actual costs may or may not stay the same.

HERMAN: There's a tremendous growth in capacity for fiber, and you wonder what's going to eat that up. It's not going to be voice, which isn't going to grow very fast. It's got to be data.

HALL: I think all the fiber that various companies are stringing across the country basically gives us one more alternative to consider. Our concern with that, or any other alternative, is the injection of yet another vendor into the picture. How many can you manage?

ISDN—the all-digital network

HT: *One area of developing technology that's receiving much attention is the Integrated Services Digital Network, or ISDN, which basically promises to provide a common network-access point for all types of traffic, be it voice, data, or video. What will ISDN mean to you?*

BADOWSKI: What *is* ISDN? Every vendor has its own version. I think it's like waiting for Godot. It's coming, so you don't change now. You just wait.

DOGGETT: I see ISDN as the only way our bank is going to get to our retail consumer [because it will, in theory, support high-speed communications services to the home]. But that won't happen for a long time. ISDN won't achieve large-scale penetration of the residential market until 1995, and that's probably optimistic. Corporate trials are already under way, however.

HALL: If it's done right, ISDN should open up some really interesting busi-

* Very-small-aperture terminal (VSAT) systems usually consist of a large central satellite dish that transmits data to, and sometimes receives data from, smaller dishes located at remote sites. The small dishes are usually less than two meters in diameter, and cost $10,000–$20,000. Transmission speeds typically range from 9.6 to 56 kbps.

ness opportunities—for example, making it very easy for a company like ours to set up electronic links with our customers without making a sizable investment. But we have two major concerns: What, first of all, will be its value-added features [the "services" part of ISDN]? And second, will ISDN truly be the same worldwide? We wouldn't want to see an American ISDN and a European ISDN—or a whole bunch of European ISDNs—so that, despite all the hype, they still couldn't talk to each other. We are watching it very closely, though, and our European telecommunications people are already involved in at least one pilot project. I'd also advise any telecommunications manager in a large company who is not already watching ISDN to start thinking seriously about it right now. I do agree, though, with the timeframe of early to mid-1990s.

DOGGETT: There's also a potential technological problem with ISDN. I'm not sure that the main switching equipment that is being put in today, such as the 5ESS, can actually handle the bandwidth and the demand. Already, 56-kilobit switching is a problem in some areas. If we can't get 56 kilobits working properly, where are we going to be with ISDN and its even greater complexity?

KELLEY: Too frequently, ISDN is talked about as a single product, but it's going to be much more evolutionary. As we develop significant software-based services and capabilities, and as standards get defined, there will be an evolutionary process toward ISDN. It will grow from the early to mid-'90s to the late '90s.

HT: *Is it possible to make equipment acquisitions today to ensure compatibility with ISDN?*

HALL: I haven't seen anybody advertising equipment that claims to be ISDN-compatible, because it's not yet possible to say exactly what that means. Three or four years from now, however, ISDN compatibility will be just another box on the checklist that everybody goes through when they decide what they're going to buy.

DOGGETT: If one now sticks with the major vendors—AT&T and the Rolms and Northern Telecoms of the world—

"The biggest challenge is to build a bullet-proof communications utility. It's very clear that the needs of the business require that."
—HALL (Digital Equipment)

"The way you go about being an effective telecom manager today is very different from the way it used to be. You have to make strategic choices."
—HERMAN (BBN Communications)

one should be fairly safe. They can't afford not to be ISDN. In fact, they are going to be the main vehicles propelling ISDN. And it may not be an issue even if you go with smaller vendors. If you write your equipment off over five years, which we tend to do these days in the voice world, then you've got some time to get the next generation of equipment.

HERMAN: The great attraction of ISDN is the flexibility it will give our networks. Because businesses and demographics are changing so quickly, we don't want networks that are nailed down to fixed end points. Private networks used to take years to plan, get in place, and test out—and they were very static. People don't have years anymore to react to communication needs. But ISDN holds out the hope of a much more dynamic approach because it will give customers access to a wide range of communications services that they can use, and be billed for, on an as-needed basis.

Network management/control

HT: *As companies get more involved in the actual running and maintenance of their own networks, what are some of the major issues?*

BADOWSKI: For our clients, the primary considerations are network management and the stability of the company supplying the product or service. Cost and technology are of secondary importance. At times, the client has chosen to go with a particular vendor—even though the technology was secondhand and the cost was more—because it was a stable company with extensive network management facilities.

HALL: You really get into interesting management situations when you start to mix all those different technologies together in the same network.

HERMAN: That's true. We've mentioned a lot of technologies today, and each one comes with its own kind of network management; if it didn't give you some control and diagnostic capability, you wouldn't buy it. But if you're an operations manager, you're faced with the problem of having maybe 10 different management systems: one for your modems, one for your T1 equipment, one for your packet network, a whole bunch of capabilities for your SNA network, and so on. Therefore the interaction between separate management systems, and the eventual integration of management systems, are key issues in planning for operations today. It's especially difficult because there are no standards, and at present there are only fledgling attempts at developing a standardized approach to network management.

The classic problem is that the user says response time is too slow. And you have a very hard time dissecting the various stages of data flow to pinpoint the various sources of delay.

HALL: One of the major challenges for us is understanding our traffic patterns from end to end. For example, in Digital's environment, it's commonplace for a computer in southern California to send a file to a computer in England. And it may go through six to eight other computers along the way. We can identify the traffic down each particular piece of that path, but it's very, very difficult to identify where it started and where it's going. Yet that's really the kind of information you need if you're going to do any kind of scientific job of network design. It gets you into measuring *what* your network is doing in addition to *how* it's doing it, and the tools you need for each tend to be very different. *How* gets into things like availability, cost-effectiveness, and performance. *What* gets in to the question of who's using it, how much they're using it, and for what applications.

For me, the biggest challenge is to build a bulletproof communications utility. It's very clear that the needs of the business require that. The network always has to be there. It has to be like electricity or running water. And in addition to meeting the basic service needs of the company, the utility must be able to serve as something that enables the company to change the way it does business, and to gain a competitive edge.

HERMAN: Yes, the management of change is absolutely critical. We all talked about the need to be flexible and dynamic. Part of network management is being able to make those changes in an orderly way without letting your network get out of control. But that's not easy, and sometimes may not even be possible. Even without growth, you've got to make sure that the thousands of little pieces of equipment in a network are all properly configured, they're all hooked together right, that you know where they are, that you know when something has to be fixed and how to get to it, and so on. This complexity can be a limiting factor in your ability to expand your network or to quickly alter it.

HT: *Do those of you who are running networks have a central point of oversight, from which you're able to monitor your traffic, tell if a piece of equipment has gone down, and do some sort of reconfiguration if necessary?*

HALL: We do, but it's not all-encompassing, chiefly because of our size. It's very difficult to monitor a network of 8000 computer systems from one place. So we take a kind of hierarchical approach to network management. This applies on the voice side as well. We have a central piece of the network, the backbone, which connects the major locations together all over the world. We monitor the backbone from a central point at our headquarters, and we'll have some local monitoring capability as well. The trick is getting all of the monitoring techniques and tools to communicate with each other.

DOGGETT: One of the reasons I want full control from my office is that I expect to see the telecommunications carriers engaging in the same type of price wars that we're currently seeing in the airline industry. I want to be able to put all my traffic on ITT if they've got a bargain rate for April going down to Miami, and I want to be able to do it at the drop of a hat, because after a month I might want to move to AT&T for a bargain to the West Coast.

HT: *How will you cope with all that?*

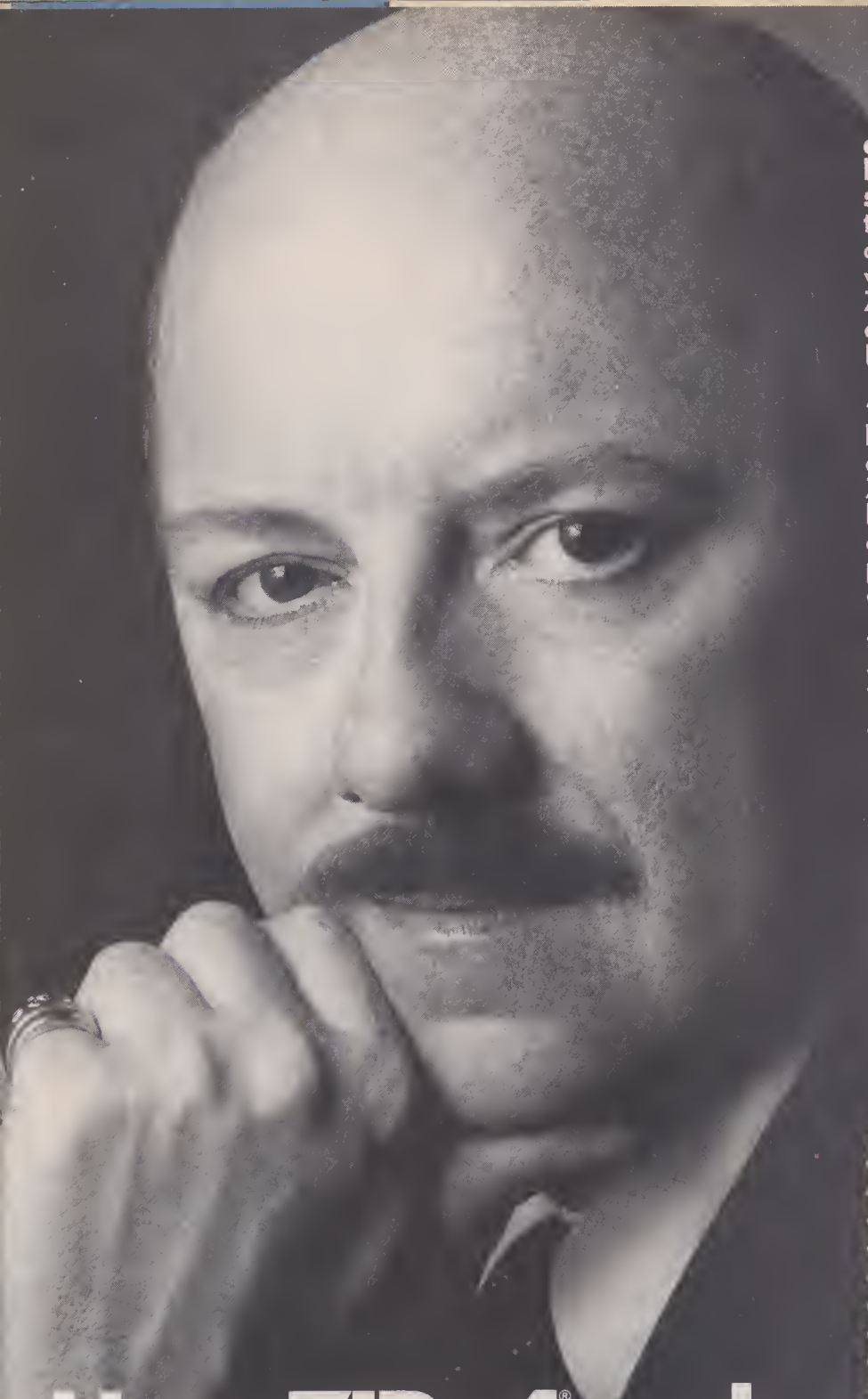
KELLEY: That's the learning process we're going through right now. Things are very different from what they were. □

For further information see **RESOURCES**, *p. 69.*

Telecommunications survey

Readers: What are *your* telecommunications needs? Please let us know by filling out the survey card (opposite p. 24) or passing it on to the appropriate person in your organization. Thank you.

The Editors



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BUILDING A BETTER TOMATO

Biotech firms are cultivating ways to make crops tastier and more appealing

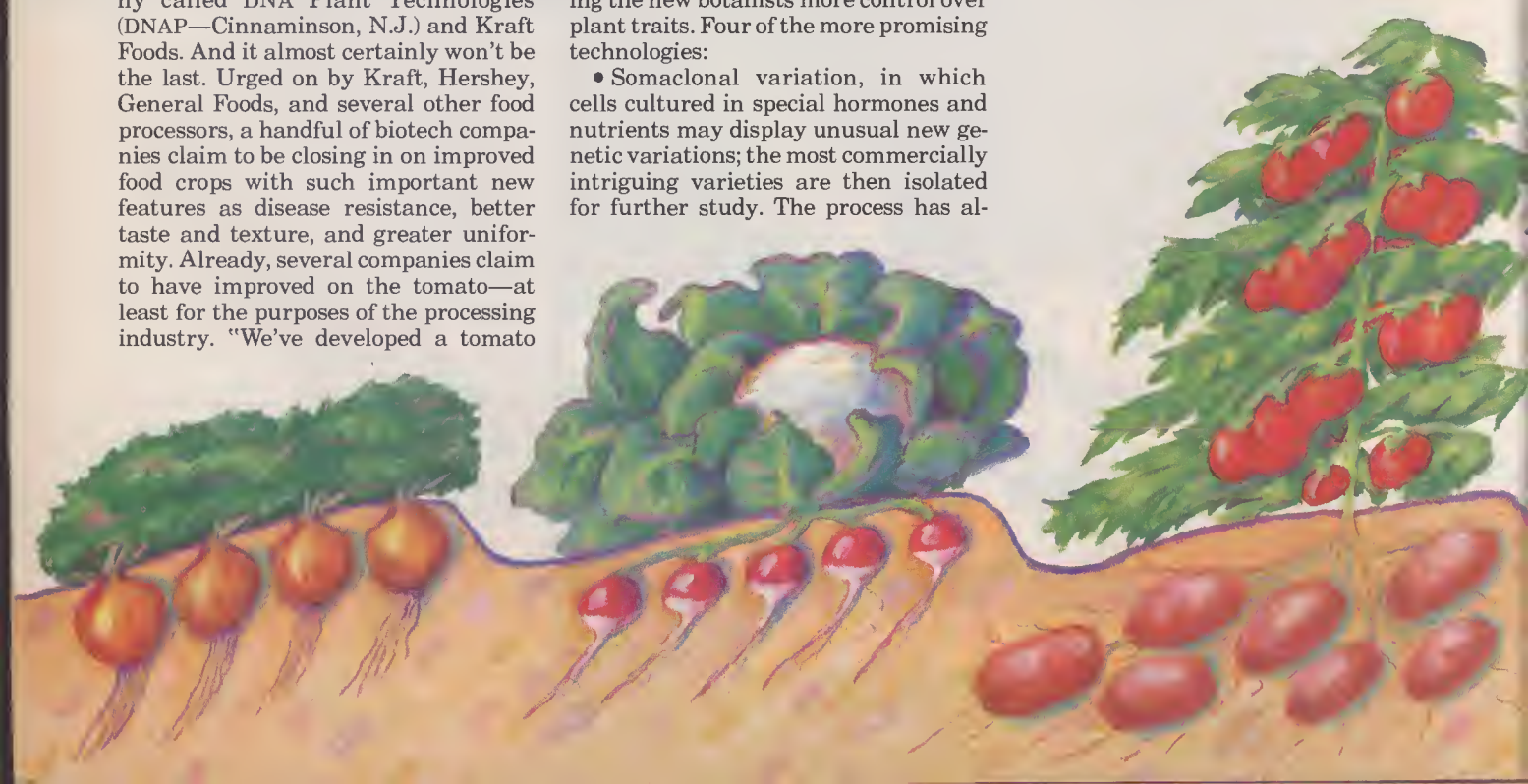
by Ricki Lewis

Any day now, snackers in selected American marketing areas will be able to crunch down on what is being promoted as the perfect celery stick. Unlike your garden-variety celery stick, say the developers, this one will keep its snappy flavor, bright green hue, and crispness for weeks, not just days. And it will be free of those tough strings that get wedged between your teeth.

Called VegiSnax, it's among the very first progeny of the recent marriage between biotechnology and the food industry—in this case, between a company called DNA Plant Technologies (DNAP—Cinnaminson, N.J.) and Kraft Foods. And it almost certainly won't be the last. Urged on by Kraft, Hershey, General Foods, and several other food processors, a handful of biotech companies claim to be closing in on improved food crops with such important new features as disease resistance, better taste and texture, and greater uniformity. Already, several companies claim to have improved on the tomato—at least for the purposes of the processing industry. "We've developed a tomato for pastes and soups that's higher in solids than the current processing tomato," says DNAP president Richard Laster. "That means that the processor will have to buy and ship fewer tomatoes and evaporate less water. All in all, processing would be much less expensive."

Just as there are many routes to building better cars or computers, so there are several methods for building better plants. All are based on asexual reproduction, so they bypass the normal genetic guesswork associated with conventional plant reproduction, offering the new botanists more control over plant traits. Four of the more promising technologies:

- Somaclonal variation, in which cells cultured in special hormones and nutrients may display unusual new genetic variations; the most commercially intriguing varieties are then isolated for further study. The process has already paid off with the VegiSnax products, and could soon bring consumers tastier tomatoes, low-calorie "buttered" popcorn, and other commercially important crops.
- Somatic embryogenesis, a technique by which cells grown in culture produce embryos that display not variety but genetic uniformity. The embryos can be encapsulated as artificial seeds that contain their own fertilizer and pesticide and that are expected to be easier to plant and harvest.
- Protoplast fusion, a method for combining two different plant cells—



and their genetic properties—into an entirely new crop that features the best qualities of both.

• Recombinant DNA, in which specific plant or microbial genes are identified and moved into a target plant. Although the widespread benefits of gene splicing are still several years off, the science stands to become the most powerful tool of all for creating new plant varieties. Already, it has created tobacco and cotton plants that produce their own insecticide.

An important advantage of these technologies is time. Whereas conventional breeding (that is, crossing individual plants) might produce a valuable new variety in 7–10 years, the new processes are expected to bear fruit in a fraction of that time. According to David Evans, DNAP's vice-president of corporate research, it will take just "18 to 24 months from when we start looking into a novel product to when we have a new breeding line."

Somaclonal variation and somatic embryogenesis are similar in that both begin with cultured plant cells—not sexual cells (gametes), as in conventional breeding procedures, but body (somatic) cells. The processes are quite simple. A small piece of tissue from an adult plant is placed in a glass vessel with nutrients and plant hormones. The cells in this initial "explant" are highly differentiated—that is, they make up specific structures, such as leaves or stems. But within a few days, the explant forms a lump of tissue called a callus, which, unlike the explant, consists of undifferentiated cells in which all the genes may be expressed. The result is that each callus cell can generate an entire new plant (a trick apparently limited to plants). After a few weeks in culture, the callus forms either tiny embryos (in somatic embryogenesis) or minute shoots and then roots (in somaclonal variation). The embryos—seeds without coats or food supplies—can be packaged as artificial seeds; the roots or shoots, the immediate forerunners of adult plants, are transferred to test tubes, where they develop further as tiny plantlets. They are later moved to a greenhouse, and eventually into a field.

For reasons that are not yet understood, a small percentage of the plants produced by each method will exhibit new traits—a brighter color, for example, or disease resistance. Nor is it clear why one callus yields an embryo while another results in a shoot. "It appears to depend on several factors," says DNAP's Keith Walker, "including the hormones, nutrients, vitamins, and salts used; the genetic propensity of the material; and the length of exposure to the culture." Researchers must simply learn by trial and error which culture conditions produce embryos or plantlets in which species.

Benefits of variation. It has been known for years that a few cells in a culture display new and unexpected heritable traits. Until recently, the phenomenon was attributed to poor culturing technique and regarded as a nuisance. But in 1981, P. J. Larkin and W. R. Scowcroft of the Commonwealth Scientific and Industrial Research Organization (Canberra, Australia) suggested that the changeling plants could be a source of agriculturally useful variants.

Even as the technology's first products come to market, however, somaclonal variation still lacks the predictability needed for long-term commercial success. "You need cells"—either individual cells in culture or cells in the form of a callus—"that can regenerate plants," says Rod Sharp, executive vice-president and scientific director of DNAP. "Potentially, all callus cells can yield a regenerated plant, but only a few actually do." The reason, he says, may be that the cells are at different stages of development and that only some of them are "ripe" to undergo genetic change.

Somaclonal variation captured the attention of plant geneticists in 1983, when Sharp and his co-worker Evans somaclonally derived a big, bright orange tomato (along with 12 other tomato somaclones) from a standard red tomato. The reason for all the interest was that changes in single genes are known to occur spontaneously—that is, in nature and without chemical stimu-

ILLUSTRATION BY DIANE JAQUITH

lation—at a frequency of about one cell per million, and not all of them appear in regenerated plants. To find a tastier natural tomato, in other words, would require screening millions of garden-variety tomato plantlets. In the Sharp and Evans experiment, however, 13 of the 230 tomato plants regenerated from cultured cells were variants—a ratio of one out of 18. (Because the cultures contained no mutagenic chemicals, it appears that the genetic changes were somehow induced by the mere act of culturing.) Somaclonal variation thus proved its technological feasibility as a faster track to new varieties than relying on nature alone.

And some of these variants were more than just botanical curiosities. Two of the plants, for example, lacked a joint between the stem and the tomato, making them easier to harvest mechanically. Two other mutants produced fruit with a higher solid content; one of these varieties is expected to appear on the market in about two years.

DNAP isn't limiting itself to tomatoes, but is targeting other markets shown by consumer research to be promising. "In popcorn," says Sharp, "we found that customers wanted bigger kernels and a natural butter flavor without the calories that butter adds. They don't want hulls that stick in their teeth, or dud kernels that don't pop." Plant researchers have known for decades that corn's sweetness is controlled by a single gene. But DNAP's search for the perfect popcorn (conducted for American Home Products, makers of Jiffy Pop and Crunch'n'Munch) involves several simultaneous genetic variations.

Other crops being explored for somaclonal variation include potatoes, wheat, corn, bananas, oil palm, and sugarcane.

Synthetic seeds. Genetic variation is not always desirable, however. In producing artificial seeds through somatic embryogenesis, companies such as Plant Genetics, Inc. (PGI), in Davis, Cal., strive to create genetically uniform products, so they choose plant varieties and hormone mixtures that minimize variation. The advantage of artificial seeds for the farmer is that the seeds guarantee a uniform crop—one in which plants mature at the same rate, for example, thereby cutting costs at harvest time. And while germination of natural seeds in the ground typically requires two weeks or more, PGI's artificial seeds start sprouting in only a day or two.

A natural seed is simply a plant embryo and its food supply, packaged in a protective shell. An artificial seed is much the same, except that the embryo arises from a callus cell grown from somatic tissue, and the seed coat is a synthetic polymer. Among the plants that readily form embryo clones, according to DNAP's Sharp, are carrots, celery, lettuce, citrus, alfalfa, coffee, date palms, and pearl millet.

The first somatic embryos—cultured from carrots—appeared in 1958, but it wasn't until the early 1980s that their potential as a basis for uniform artificial seeds was recognized. In order to be marketable, PGI researchers realized, such seeds needed not only viable embryos but a packaging and delivery system as well. PGI's system, Gel-Coat, is a transparent polysaccharide gel containing nutrients, amino acids, and the necessary plant hormones. The gel is surrounded by a biodegradable polymer (also a polysaccharide) that prevents the seeds from clumping together as they're planted.

To assure uniform maturation rates (and therefore one-step harvesting), the development of all the embryos is arrested at the same stage with a controlled combination of nutrients. The company is now working on commercial scale-up methods and equipment, says PGI president Zachary Wochuk, with "full-scale commercialization probably a year or two away."

Artificial seeds can carry built-in growth enhancers like insecticides or fertilizer.

Why would a farmer use artificial seeds when nature provides a perfect biological package? For many crops, natural seeds are indeed the best bet, but for certain hybrids, artificial seeds guarantee uniform, high-quality crops that are otherwise unobtainable. In traditional breeding, variety A crossed with variety B might produce hybrid C—say, a large, juicy fruit. But that fruit might have tiny seeds that do not produce vigorous offspring, or may lack seeds entirely. And even if seeds of hybrid C are planted, the next generation is not a uniform crop of the hybrid, but (as in human reproduction) exhibits a mixture of traits, desirable and otherwise, from the parents. With artificial seeds that are genetic replicas of hybrid C, each planting season guarantees a constant crop.

So far, PGI's biggest success in artificial seeds is the celery plant. "It lent itself well to tissue culture, somatic embryogenesis, and encapsulation," says Wochuk. The celery seeds will be the first to appear on the market (in two to four years, according to marketing director Joseph Picard), and will probably be joined later by lettuce, cotton, and alfalfa, and maybe corn and rice.

A corollary advantage of artificial seed technology is that the seed package can carry insecticides, herbicides, fertilizer, nitrogen-fixing bacteria, and even tiny parasite-eating worms. PGI claims that by eliminating the need for these steps later in the growing cycle, the built-in growth enhancers may offset any cost differential between conventional and artificial seeds. (In the case of hybrid celery, for example, Wochuk estimates that the GelCoat seeds themselves will cost about 3½¢ per plant, versus 2½¢ for today's varieties.)

For now, PGI appears to be the frontrunner in artificial seed technology, because it is the only company both growing and encapsulating embryos. DNAP has a joint venture with Arthur D. Little to scale up somatic embryo cloning, but is far behind PGI in packaging technology, according to DNAP spokesperson Fred Spar. PGI is already working with Ciba/Geigy (Ardsley, N.Y.) to encapsulate a fungicide with somatic embryos to protect the developing plants against disease. And in another venture, microscopic nematode worms are packaged with the seeds; after germination, the harmless worms eat insect larvae that could damage the plant. At present, says Picard, the company is "fooling around with just about everything."

Two become one. Protoplast fusion (combining the contents of two completely different plant cells) is another way of bypassing the uncertainties of sexual reproduction. While this method promises to create entirely new crop varieties by overcoming sexual incompatibility between species, reproducible results are still down the road.

The protoplast is the living part of the cell—the gel-like cytoplasm, the DNA-containing nucleus, and various cell structures (organelles) that carry out vital reactions—contained within the cell wall. Dissolving the walls with enzymes somehow permits protoplasts to fuse together, even protoplasts from different species or genera. Such fusions occur spontaneously at low rates, but they can be induced by exposing the protoplasts to the chemical polyethylene glycol or to short pulses of electricity.

After fusion, the culture medium is altered to enable a new cell wall to form around the fused protoplasts. Sometimes this fused cell divides to form a callus, from which embryos or plantlets grow. The resulting plants, called somatic hybrids, display some character-

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Four ways of improving on nature

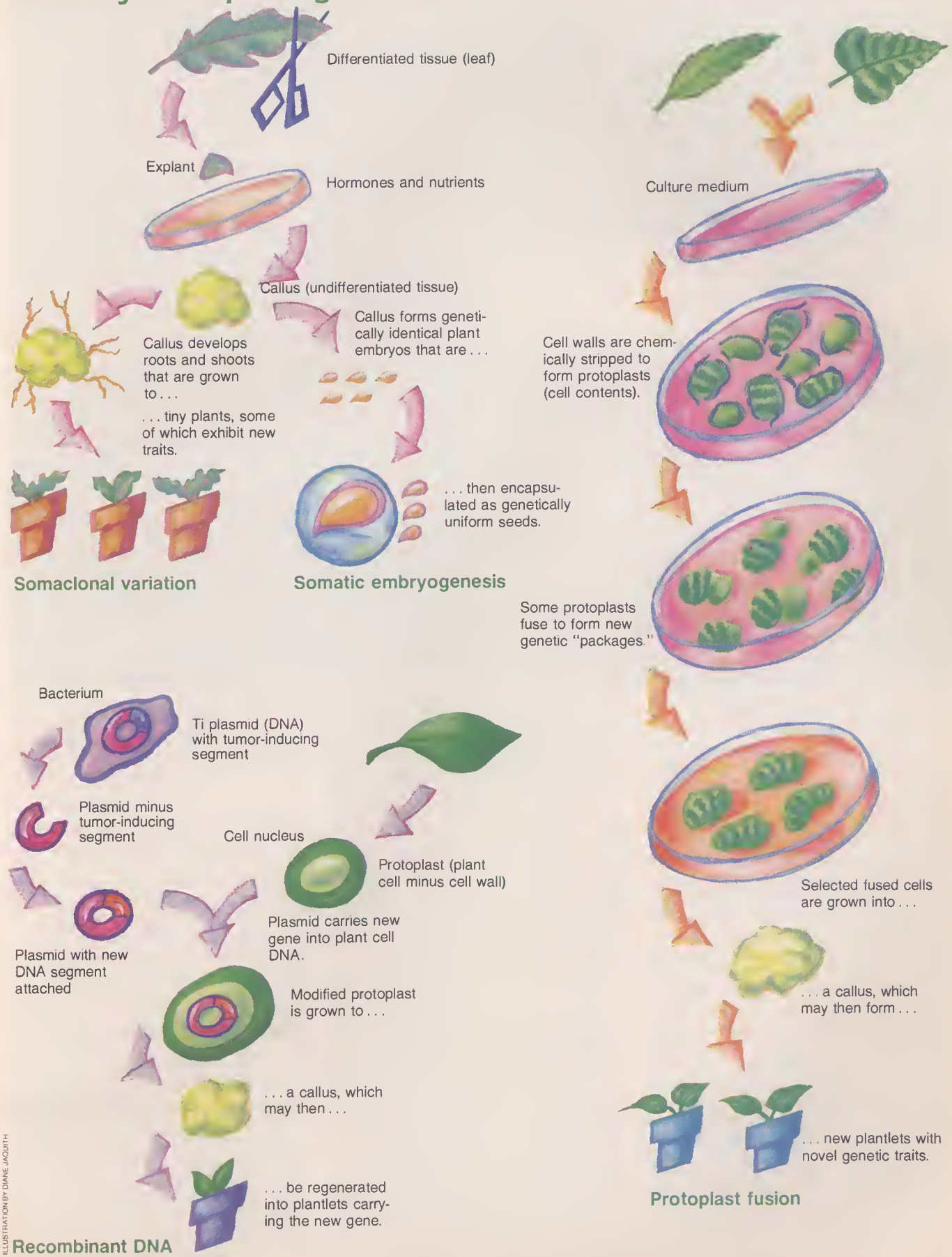


ILLUSTRATION BY DIANE JAQUITH

istics of each parent protoplast.

The process has several benefits. For example, a protoplast of a cultivated crop that is susceptible to a certain disease can be fused with a protoplast of a wild relative with natural resistance to that disease; researchers then look for a regenerated plant that combines the most desirable traits of both plants. In one such fusion, researchers at the Weizmann Institute of Science (Rehovot, Israel) recently endowed potatoes with resistance to the herbicide triazine by fusing protoplasts from the potato and one of its relatives, the wild black nightshade. Similarly, Advanced Genetic Sciences (Oakland, Cal.) has introduced triazine resistance into tobacco.

Not all somatic hybrids prove useful, of course, especially when the protoplasts come from widely divergent plants. The so-called pomato—a hybrid of a potato and a tomato—produced potatoes below ground and tomatoes above, but both were small and yielded poor-quality seeds. The same was true of a carrot–parsley fusion. Less useful still was a somatic hybrid of cabbage and radish; it sported cabbage roots and radish leaves but the edible parts of neither.

What can't be achieved through direct fusing of protoplasts can sometimes be done through complex breeding schemes that transfer wild traits to cultivatable strains in a roundabout way. One subject of such research is tobacco (the genetics of which are very well known, making it a popular model system for genetic manipulations). The wild, disease-resistant tobacco species *Nicotiana repanda*, for example, won't crossbreed with cultivated tobacco (*N. tabacum*); however, it does cross with a somatic hybrid of that species and another wild species, *N. nesophila*. Once *N. repanda* is crossed with the hybrid (combining the traits of the three species), conventional breeding with cultivated tobacco yields a variety that is disease-resistant and cultivatable.

A new use of protoplasts that is being explored at DNAP and elsewhere focuses not on the DNA-packed nucleus but on the cell's organelles, some of which also house genetic material. "Several special traits are controlled by the organelles," says Evans, "specifically by the energy-providing mitochondrion and the chloroplast, which extracts chemical energy from sunlight during photosynthesis. Their DNA is similar to microbial DNA in size, structure, and organization, and is therefore easy to manipulate by well-known methods." Mitochondrial and chloroplast DNA governs such traits as resistance to disease and herbicides, and more efficient photosynthesis.

A technique called cybridization is being used to shuttle organelles from one cell to another. Just before two protoplasts are fused, one of the nuclei is inactivated with radiation. The fusion product, called a cybrid, thus has only one nucleus but contains organelles from both protoplasts. As the hybrid cell divides, some organelles are lost; but researchers can select the cells whose remaining organelles will yield the desired characteristics. Ways of isolating organelles and directly transferring them between protoplasts are still being worked out.

Protoplast fusion has its limitations. A typical fusion gives a mixed bag of results—single cells, fused cells of the same kind, and the sought-after fused cell of two different types. And only some of these fused cells divide; the others simply die. (Those that do form embryos or plantlets include asparagus, rapeseed, cabbage, citrus, sunflowers, carrots, cassava, alfalfa, millet, clover, and endives. Because of the high cost and difficulty of handling the plantlets on a large scale, however, none are presently cultivated commercially.) What's more, the combination of traits in a somatic hybrid is not predictable, and sterility is common.

A long-term goal of agritechnology is to engineer crops to fix their own nitrogen.

Researchers can sometimes exercise control over the fusion product with a technique called mutant selection: Protoplasts grown from callus are exposed to an herbicide, which kills most of them. But a few survive because of preexisting mutations that render them resistant to the chemical. If such a resistant cell can regenerate a plant, that plant and its progeny may also be resistant.

Mutant selection—which can be applied to any cells in culture—is enabling herbicide and plant genetics companies to develop resistant plant varieties, so that the chemical destroys only surrounding weeds. Molecular Genetics (Minnetonka, Minn.), for example, has recently treated corn cells in culture with American Cyanamid's imidazolinone herbicide, then isolated and scaled up mutant corn plants that are resistant to the chemical. Pioneer HiBred International (Des Moines) is developing Molecular Genetics' resistant corn into a proprietary seed for American Cyanamid; the program is expected to reach commercialization within five years. And DuPont (Wilmington, Del.) has mutant-selected tobacco plants that are resistant to its chlorosulfuron and sulfometuron herbicides.

Splicing better crops. Although gene splicing, or recombinant DNA (rDNA) technology, is still considered the most futuristic of the new agritechnologies, it could have the greatest impact. Certain bacterial genes could confer on plants built-in resistance to disease, herbicides, insecticides, salt water, and low temperatures. And while these features often appear by means of other cellular manipulations, gene transplantation is a much more precise method for imparting new properties.

The basis of rDNA technology is that all organisms use the same genetic language. A gene from a broccoli plant, for example, would make its protein even in a sunflower. But rDNA work on plants has lagged behind that on lower organisms, largely because of the difficulty of getting foreign DNA into plant cells; it is no simple matter for the transferred DNA to make its way into the plant cell nucleus. (In contrast, bacteria have no nucleus, so migration and recombination are much simpler.) And even if the new genetic material finds its way into the plant nucleus, that cell doesn't always go on to regenerate fertile plants.

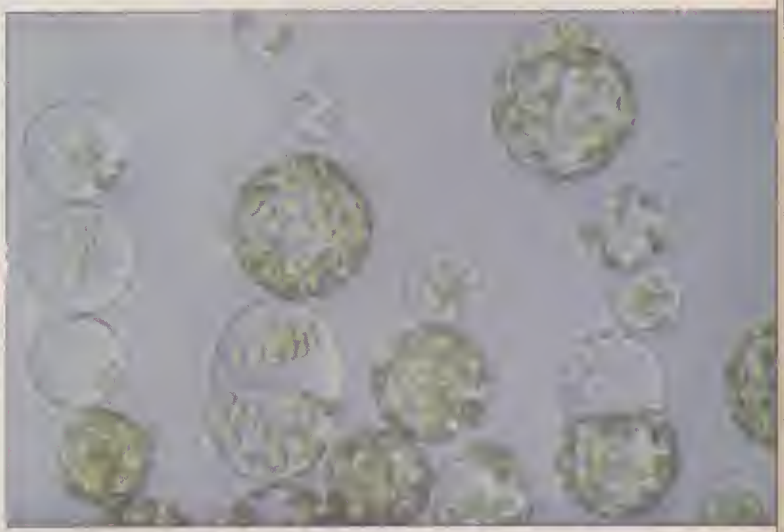
Several vectors, or transport systems, for DNA have been developed, but—among other problems—each works only for certain plant species. So far, gene transfer is farther along for the dicots (plants whose seed consists of two distinct segments, such as potatoes, tobacco, alfalfa, soybeans, petunias, and tomatoes) than for the monocots, which include the important cereal crops. Nevertheless, as researchers find new routes and new combinations of technologies, the list of plant species suitable for rDNA methods is growing.

A popular vector for introducing genes into the cells of many dicots is a small ring of DNA called the Ti (tumor-inducing) plasmid, found in the microorganism *Agrobacterium tumefaciens*. Normally this plasmid enters plant cells and causes a cancerlike growth called crown gall disease. But the tumor-causing DNA sequence of the plasmid can be chemically removed without impairing the plasmid's ability to insert itself and take up residence in a cell nucleus, with foreign genes artificially hooked on. Other vectors under study include the Ri (root-inducing) plasmid of *Agrobacterium rhizogenes*—which causes plant hairy root disease—and the cauliflower mosaic virus.

Several companies have used rDNA

Agracetus's Winston Brill examines experimental cotton plants. One of the company's goals is to genetically engineer the crop—which is highly prone to insect attack—so that is manufactures its own insecticide.

Synthetic seeds (in this case alfalfa) consist of plant embryos and a supply of nutrients encapsulated in a biopolymer for easy planting. Unlike conventional seeds, they offer uniform genetic traits and maturation times.



In protoplast fusion, individual plant cells are stripped of their walls, then merged to create new cells. The resulting hybrid cells combine the genetic properties of both parents, and can often be made to regenerate into adult plants.

SCOTT WITTE (LEFT); PLANT GENETICS (RIGHT)

technology to endow crop plants with genes for resistance to specific herbicides. At Calgene (Davis, Cal.), for example, a gene conferring resistance to glyphosate has been isolated from the bacterium *Salmonella typhimurium* and transferred into tobacco via the Ti plasmid. Glyphosate kills plants by interfering with the enzyme EPSP synthase, which is needed to make the essential amino acids tryptophan, tyrosine, and phenylalanine. EPSP synthase produced by the bacterial gene differs chemically from the tobacco variety in a way that enables it to synthesize the three amino acids even in the presence of the herbicide.

The bacterial-based plant protection isn't at a marketable level yet, according to David Stalker, principal scientist at Calgene, because the new enzyme (which the company has patented) doesn't make its way to the chloroplast, where it is normally used. As researchers try to find an effective delivery system, they will also test the technique on tomatoes, cotton, and soybeans.

Researchers at Monsanto (St. Louis), meanwhile, have used a specially engineered Ti plasmid to impart glyphosate resistance to petunias. The plasmid contains not only the normal petunia EPSP synthase gene but also a section of viral DNA that overstimulates the gene. As a result, the petunias produced enough of the enzyme to counter the glyphosate. To get the enzyme into the plant chloroplasts, Monsanto's Robert Fraley and his co-workers have included in the plasmid a gene that produces a delivery system called a chloroplast transit peptide. The result is a vector that not only stimulates the production of extra enzyme—thus providing 10 times the glyphosate resistance of ordinary petunias—but also delivers it to where it's needed.

A way to avoid searching for the vector that best suits a given plant may be to transfer DNA directly into plant cells by culturing protoplasts along with foreign DNA, which migrates into the protoplast. Such genetic mixtures occur in nature, though at low frequencies. In the method called electroporation, a brief jolt of electricity is sent through the protoplasts, temporarily opening up membrane pores that allow DNA in. Michael Fromm and co-workers at Stanford's biochemistry department have transferred a gene for antibiotic resistance into corn protoplasts—a major feat in genetic engineering for this economically important but hard to manipulate crop. (The goal was not to create a healthier corn plant but to show that a gene could be directly transferred.) But a big problem remains. "We've transformed corn protoplasts and have grown callus," says Fromm, "but we haven't yet been able to regenerate corn plantlets. No one's been able to do that, for any cereal. It will happen, but it's a question of when. I'd predict a year or two."

Plant technology: a growing market

Somaclonal variation and other techniques for manipulating plant cells in tissue culture are substantially reducing the time required to create new and improved plants. Several companies have begun marketing products derived from these biotechnologies, and many more are now being field-tested. The annual value of the U.S. market for seeds derived from somaclonal techniques will grow from about $8 million in 1985 to $190 million in 1990, predicts George Kidd, advanced-science consultant at the agricultural consulting firm of L. William Teweles (Milwaukee).

DNA Plant Technologies (DNAP—Cinnaminson, N.J.) is generally considered to be a leader in this field. Native Plants (Salt Lake City), Plant Genetics and Calgene (both in Davis, Cal.), Sungene Technologies (Palo Alto, Cal.), Molecular Genetics (Minnetonka, Minn.), and Crop Genetics International (Dorsey, Md.), also have substantial plant-tissue programs. Besides competing among themselves, these research-oriented companies must also contend with many well-established firms such as DeKalb-Pfizer (DeKalb, Ill.), Pioneer Hi-Bred International (Des Moines), Monsanto (St. Louis), and DuPont (Wilmington, Del.) and with commercial horticulture facilities operated by such companies as Weyerhauser (Tacoma, Wash.) and George J. Ball (West Chicago, Ill.).

"Commercial prospects for new plant products may be inhibited by the difficulties of scaling up production and by the limited number of talented people trained in plant genetics."

Hugh Bollinger
VP for Strategic Planning
Native Plants

The new processes are being used to develop a wide range of fruits, vegetables, and flowers. Native Plants, for example, hopes to tap the $3 billion annual retail flower market with new horticultural varieties of ornamental roses. The flowers will bloom in as little as two months (compared with a year for conventional roses) and can be mass-produced through tissue-culture techniques for year-round distribution to retailers. "However, Native Plants will be competing directly with entrenched flower producers in what has been a flat market until now," cautions Jeanne Jones, president of the Horticultural Evaluation and Review Service (Dallas). "Unless the new companies help expand that market—which they might do by opening up sales to supermarkets and discount stores—they aren't likely to get anywhere."

Several firms are working on new varieties of corn, potatoes, sugarcane, and other food crops. Molecular Genetics and Sungene are developing corn that is resistant to blight. Sungene is also working on corn that produces superior yields; for instance, if the ears of corn sprout lower on the stalks, the plants are less likely to blow over in the wind. Molecular Genetics is tailoring its corn to resist a specific weed killer, Scepter, made by American Cyanamid; such corn could then be grown with impunity along with liberal use of the herbicide to control weeds. Hybrid seed corn is currently a $1 billion market, with half the sales going to Pioneer Hi-Bred. "We anticipate gaining 5% of this market over the next few years with selected corn variants, if we can find partners to help in scaling up the volume of operations and in marketing our product," says William Reid, president of Sungene.

Plant Genetics and Native Plants are preparing potatoes grown from seed that are disease-resistant and easy to handle. Production of premium seed stocks is just beginning, but could grow to a $28 million North American market within ten years, says Valerie Ventre, marketing manager at Plant Genetics. And Crop Genetics is attempting to create a market for its disease-free, improved-yield sugarcane stalks.

DNAP has targeted the food processor and consumer markets with a variety of products. VegiSnax, for example—a package of somaclonally bred carrots and celery featuring special color, texture, and taste qualities, such as crispness and sweetness—is being field-tested and promoted by Kraft. DNAP is also aiming for a share of the $500 million tomato-processing industry with a new tomato being field-tested under contract to Campbell Soup. At present, processing facilities use a tomato that is 95% water. Boosting a tomato's solid content from 5% to 6%, as DNAP is doing, is worth about $80 million a year to processors, says Teweles's George Kidd. "Operating costs are lower, and fewer tomatoes are needed to make the same number of cans of tomato paste or sauce. That's impressive leverage from such a seemingly small change."—*Jeffrey L. Fox*

"Consumers are looking for healthful diets as an aid to total well-being. This opens up a new market for biologically tailored food products that are enjoyable and nutritious."

Richard Laster
President
DNA Plant Technologies

NEW JERSEY NEWSPHOTOS

Cellular manipulation often leads to interesting new crop variations. For example, pea-size potatoes from Plant Genetics may one day appear as commercial greenhouse plants. For now, they serve as repositories for their unusual genetic information.

Monsanto's Robert Fraley imparted herbicide resistance to petunias with a specially engineered piece of DNA called a Ti plasmid. As a result, the flowers counteract the herbicide by producing an excess amount of a vital enzyme.

Nutritional qualities can also be altered with rDNA. SeedTec International (Woodland, Cal.), for example, is working on a sunflower that produces seeds with higher oil content. Sunflower seeds have also been engineered to produce a highly nutritious protein called phaseolin, found in the bean *Phaseolus vulgaris*; the seeds have greater amino acid diversity and thus could serve as a better-balanced protein snack. In addition, Molecular Genetics was awarded a patent last October for corn plants, seeds, and tissue culture with boosted levels of tryptophan, an amino acid that is believed to lead to more nutritious seed corn.

A long-term goal of agritechnology is to engineer crop plants to fix their own nitrogen—that is, convert biologically useless atmospheric nitrogen into a form that plants can metabolize, such as ammonia. The task is now accomplished by costly fertilizers, or in some plants by natural bacteria such as *Rhizobia.* Attempts to improve nitrogen fixation through genetic engineering have focused on the bacteria—either by increasing the efficiency of *Rhizobia* in the natural host plant or by altering the bacteria so that they can colonize a wider range of plants. The ultimate goal, however, is to transfer bacterial genes for nitrogen fixation into crop plant cells, then regenerate the cells into whole plants.

That's a tall order. There are 17 known bacterial nitrogen-fixing genes, but no known vector to transfer them into cereal crops such as corn. What's more, even if the right genes can be placed in the right plant cells, regeneration of the whole plant will still be a major obstacle. Agracetus (Madison, Wis.) is in its third year of field trials of altered microorganisms that are more efficient nitrogen fixers; but for now, company sources decline to discuss specific results of the trials.

Like most other plant genetics companies, Agracetus has targeted market niches. "Most of our work in plant genetic engineering is trying to get plants to use less pesticide," says Winston Brill, director of Agracetus. Working with the organism *Bacillus thuringiensis*, company researchers recently moved a gene that produces a compound fatal to preying caterpillars into tobacco and cotton cells. The regenerated plants can now manufacture their own insecticide—a feat that Brill is convinced might one day "turn the agrichemical industry upside down" by making some synthetic insecticides obsolete. However, he cautions, "this isn't going to happen in the next five years."

The new and improved veggies soon to debut in the marketplace are just the front-runners in a novel approach to agriculture that promises to reverberate throughout the business sector, as well as down on the farm and on the supermarket shelves. "Biotechnology will give farmers healthier crops that are better adapted to local conditions, enabling companies to respond to micromarkets more readily," says Joseph J. Molnar, associate professor in the department of agricultural economics and rural sociobiology at Auburn University (Auburn, Ala.).

In the eyes of DNAP's Laster, the main beneficiary of the new agritechnologies will be the consumer. "Produce is increasingly recognized as an important aspect of good nutrition," he says. "If you look at the diets now recommended by the American Heart Association, the American Cancer Society, and the Food and Nutrition Board of the National Academy of Sciences, they all say the same thing—eat more fiber and less fat. By enhancing a fruit or vegetable's taste, convenience, texture, flavor, and aroma, biotechnology will make those products more appealing, adding to the health of the consumer." □

Ricki Lewis is a freelance writer with a PhD in genetics from Indiana University. She teaches genetics at the State University of New York/Albany.

For further information see **RESOURCES**, *p. 69.*

Coordination unlocks

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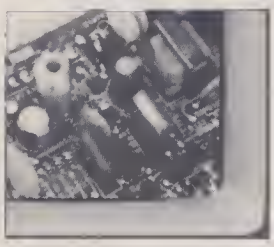

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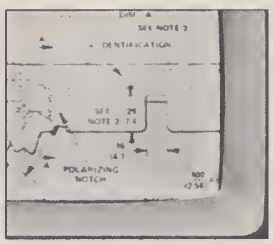

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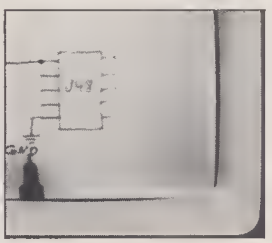

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THE LONG AND SHORT OF COPIERS

New Japanese machines range from hand-held to billboard-size

Matsushita's massive copier produces images as large as 23 × 52.5 feet—suitable for billboard advertisments.

Many methods of communication that are taken for granted in Western countries are difficult or impossible in Japan. Because typewriters, telex machines, and, until recently, computers have been unable to handle the thousands of kanji characters, the vast majority of correspondence in Japan—even between the most modern corporations—has always been handwritten. To automate the dissemination of these written pages, the Japanese turned to copiers and facsimile machines, which, as a result, became the most important pieces of equipment in Japanese offices.

It is natural, therefore, that Japanese manufacturers have devoted substantial resources to developing image reproduction equipment, and that they have successfully enhanced and repackaged the basic xerographic technology to exploit new applications and markets. Three products introduced recently in Japan carry on this tradition, being either bigger, smaller, or more convenient for editing originals than previous copier machines. Each of the systems is already being marketed in the United States, or soon will be.

Possibly the most representative of the Japanese customer-driven approach—the E2S Editing System—is made by Matsushita for marketing in the U.S. under the Panasonic name. The E2S lets users select portions of a page to be reproduced, without the need to cut or mask the original.

The editing system, an accessory that can be used with the Panasonic 1520, 2625, and 3030 copiers, consists of a stylus-input editing tablet that can be placed on a stand next to the machine or on the copier's lid. The user places the original, or a working copy, on the tablet and presses the stylus first at the corners of the area to be copied, then in a "print" box at the bottom of the tablet. Only the area inside the indicated points appears in the resulting copy. Matsushita calls this a "trimming" function.

Selected areas can also be shifted in position, enlarged, or reduced. Rectangular boxes can be selected merely by pressing at two corners, but for more complex shapes all corners must be indicated. The editor recognizes only right angles and an even number of corners, so triangles will not register, and trapezoids appear as rectangles.

The mechanism supporting these functions is fairly straightforward. The editing option works with copy machines that employ conventional photoconductive drum mechanisms, which carry a positive charge. Light reflected from the original's white areas neutralizes this charge, so that negatively charged toner attaches only to parts that are dark on the original.

Copiers compatible with the editing option contain an additional component—a row of 124 LEDs, at 2.5-mm intervals across the width of the drum. The editor reads the coordinates input to the tablet, and converts them into instructions that turn LEDs on and off at the proper time during the drum's rotation, erasing the unwanted areas.

The E2S's other functions are accomplished in a similarly straightforward manner. To move an image from one part of the page to the other, the scanning of the original is merely advanced or delayed in relation to the rotation of the drum. Thus, shifting can occur only parallel to the scanning direction. "Zooming," or optically enlarging or shrinking the copied image, requires two simultaneous operations. The width (the dimension perpendicular to the scanning direction) is changed optically through the movement of lenses. The length is altered by increasing or decreasing the scanning speed of the optical housing in relation to the rotation of the drum.

The editor has a number of other functions using the same basic mechanisms of trimming, shifting, and zooming. For example, if the original is a

by Bob Poe

book or magazine, the "book" mode deletes the center line between the pages. "Edging" puts a margin around the edges of the copy. "Centering" automatically places a section selected by the trimming function in the middle of the page lengthwise. The E2S option, which retails for $695, has been available in the U.S. for almost a year.

The smallest of the three new products is a pocket-size copier recently introduced by Plus Corp. Called the Copy Jack, the device is less than seven inches long and weighs less than a pound. It is meant for use when only a few lines of information need to be copied, or where conventional copiers are not available. A narrow, 33-foot roll of thermosensitive paper permits 1.6-inch-wide strips of information to be copied.

The hand-held Copy Jack makes 1.6-inch-wide copies as the user draws it across a page.

Operation is simple. A user holds the Copy Jack perpendicular to the sheet to be copied, pressing the scanning end against the paper and drawing the machine across the surface. Contrast is adjustable, and density depends on scanning speed, with one centimeter per second said to give optimal results.

Though the Copy Jack's packaging is innovative, its electronics are fairly conventional. An array of 22 LED chips illuminates the surface to be copied. The reflected image passes through a lens and is converted to digital electronic signals by 1024 charge-coupled devices (CCDs). Custom chips process the signals and control 320 nib heating elements, which transfer the image to the paper. Power is supplied by rechargeable nickel-cadmium batteries.

The Copy Jack will be available in the U.S. this month or next, according to Debbie Herrmann, marketing administrator for Plus USA (Closter, N.J.). Although the price hasn't been firmly set, it should run about $300.

At the opposite extreme is the most spectacular of the three: Matsushita's Full-Color Jumbo Facsimile System, a giant color copier with editing functions and the ability to accept images sent from remote locations over phone lines. It produces precise copies up to 23 × 52.5 feet from conventional color photographs, positive transparencies, and negatives, or from electronically manipulated composites of such originals. The first machine was recently delivered to a Los Angeles advertising company that is using it to produce billboard ads.

The product consists of two separate subsystems: one to scan originals, process and edit the digitized images, and store the resulting composites on a 67-megabyte cartridge tape; the other to print enlarged pictures from the stored information. A single image processor/editor subsystem can serve any number of remotely located enlarging printers merely by sending copies of the original cartridge tape. Thus a central design office could produce ads for billboard displays nationwide. Both subsystems are based on Hewlett-Packard 16-bit microcomputers.

In the first processing stage, photographic negatives or positive prints up to international A4 size (approximately 8 × 11.5 inches) are taped to a glass cylinder several inches in diameter. The cylinder then rotates while a light source (internal for negatives, external for prints) moves parallel to its axis. Scanning resolution is variable from 20 to 1000 microns per line in 5-micron increments. The light passing through the negative or reflected from the print is separated by a combination of dichroic mirrors (which reflect light of one color and transmit that of the other colors) into beams of the three process colors—yellow, cyan, and magenta. The separate beams are read and converted by photomultipliers into electrical signals for storage on a magnetic hard disk.

Once the pictures are scanned and stored, they can be manipulated by the image processor to produce the desired composite image. Using a mouse for input, the designer can place the stored images at any location in any size on the processor's color screen, alter colors, add backgrounds, paint or fill designated areas, and generally manipulate the image elements to produce a wide variety of results. Also, the image can be enlarged on the screen for detail work. After the composite image is approved by the designer, it is printed out on a standard-size thermal transfer color printer for proofing, and stored on the cartridge tape.

The enlarging printer subsystem is a huge machine consisting of two aluminum alloy drums (each 8.2 feet in diameter and almost 30 feet long), a supporting frame, and an operator's control station. Paper or some other flexible material is taped to the drums, often in four-foot-wide strips for ease of handling. With the drums rotating at 12 rpm, four vertically aligned nozzles move along the drums and spray ink—the three process colors plus black—at the precise spots necessary to produce the desired final image. The ink is blown onto the surface by compressed air, the flow of which is restricted by electromagnetic diaphragms in order to control the volume of ink. For uniformity of hue, the ink must be applied in one pass across both drums. A separate set of nozzles on the back of the machine applies a protective resin after the ink has dried.

The speed at which a copy can be produced depends on the desired resolution. The horizontal lines can be spaced every 2, 4, 6, or 8 millimeters. At the 2-mm pitch, a full-size print using both drums normally requires 11 hours. However, this time can be cut in half through the use of an optional second vertical row of four nozzles located next to the first. The secondary nozzles can also be used to produce a thicker coat of ink, which is sometimes needed on translucent surfaces that are used for backlit displays.

Hand painting, by contrast, often requires up to two weeks to produce a single billboard ad. Matsushita hopes to sell 20 to 30 systems within three years for about $2.25 million each.

None of these three new copier products is technologically startling, but all exemplify the attitudes and methods that have made the Japanese leaders in so many fields. "What the Japanese are doing is really classic marketing," says Raymond L. Boggs, manager of the office equipment group at Venture Development (Natick, Mass.), a consulting and market research firm. "They're looking at what the customer really needs and are meeting those needs to build a new business area. □

Bob Poe, who lives in Tokyo, reports regularly on Japanese technology.

HARD DISKS PUT PC'S ON THE FAST TRACK

Megabytes no longer cost megabucks, but choosing a drive can be difficult

Hard or Winchester disk drives traditionally have been regarded as a luxury option for microcomputers, an expensive way to get high storage capacity and better performance. But dramatic price reductions are now making hard disk drives standard equipment in desktop computers, and software developers are taking advantage of the trend by producing large, complex programs that require hard disks for operation. As the price of basic 10-megabyte (MB) hard disk drives for the IBM PC drops below $500, everyone with a floppy disk computer should consider adding a hard disk.

Selecting a hard disk drive, however, is no simple matter. Although floppy disk drives come in only a few basic types, hard disk drives present major differences in capacity, performance, physical size, and other features.

The most obvious distinction among hard disk drives is capacity. The smallest-capacity drives now in volume production hold 10 MB, while the largest hold 236 MB and prototypes hold up to 640 MB. Despite the common argument that you can never buy enough storage, a typical user will probably find 20 MB sufficient for older, text-based software, while those doing a great deal of graphics work will generally need more. The most cost-effective drives, on the basis of price per megabyte, are the 72-MB models. (Capacity figures in this article all refer to formatted storage. Unfortunately, some advertisements, particularly for IBM PC/AT disk drives, quote unformatted capacity, which is typically 20% higher than formatted capacity.)

Physical size is another major difference. High capacity is easier to design into a large drive. In microcomputers, the widest range of features comes in the full-height 5¼-inch size. Half-height 5¼-inch drives also sell well, but are limited thus far to 40-MB capacity. As a result, computers that permit only half-height drives, such as the Tandy 3000 and Hewlett-Packard Vectra, restrict your choices significantly. In the smallest size, the 3½-inch micro-Winchester, only 10- and 20-MB models are currently available.

The key issue in performance is how fast the hard disk drive can get to and retrieve a particular piece of information. The data on all magnetic disks reside in concentric circles, or tracks, that are written on and read by a magnetic head moving over the disk's surface. Each track comprises several sectors with a fixed amount of data, typically 512 to 1024 bytes. The disk operating system maintains a directory of all the information, listing which tracks and sectors each file occupies.

The time required to retrieve information depends on how quickly the head can move to a particular track and how long it takes to read and transfer the desired sector to the computer's memory. The most commonly quoted figure is average access time—the average time required for the heads to seek out a particular track. In floppy disk drives with just 40 tracks, this is typically over 100 milliseconds. Low-performance hard disk drives, such as those used on the original IBM PC/XTs, had access times of about 100 milliseconds across 305 tracks. These drives use stepper motors to move the heads over the disk, so the motor must ratchet through many steps during a typical disk access. Such drives now have faster access times (about 65 milliseconds), but are still low-performance by modern standards.

Other head-movement motor types improve performance. Linear motors, such as those on standard IBM PC/ATs, achieve a medium access time: 35–40 milliseconds. High-performance drives use voice coil motors, in which the heads are mounted like the cones of a loudspeaker. Access time is 20–30 milliseconds.

(Still faster access times are possible by reducing the distance the heads must move. Nearly all hard disk drives use just one head per surface, which must traverse the entire disk. The Atlas drive for minicomputers reduces access time to 18 milliseconds by using four heads per surface; this cuts by three-quarters the maximum distance the head must move.)

Within this mechanical limitation, designers of operating system software try to set up information on the disk so that "head seeks" are kept to a minimum, and so that the head must move no farther than to the next track. The head can typically move to an adjacent track in a quarter of the average access time. To cut down on head seeks, a drive should read and write as much information as possible while the head is in a specific position. Designers take advantage of the track geometry on hard disks to optimize these factors.

A floppy disk has two surfaces, a top and bottom, which are recorded and read in an alternate top/bottom sequence. In this way, the heads need not move until all possible information has been written or read. Hard disk drives carry this idea further; they typically have two or more magnetic platters with a head on each surface. A two-platter drive has four heads, and a four-platter drive has eight heads. The heads always move together; by using each surface in turn, a hard disk drive can store much more information than a floppy drive before the heads must move, thus saving head seeks.

Taken together, all the tracks for a particular head position form a set of constant-diameter circles called a cylinder. The heads on a doubled-sided 360-kilobyte (kB) floppy disk must step to another track after reading only a 9-kB cylinder, compared with a 32-kB cylinder on a typical 10-MB hard disk. On a large hard disk such as the CDC Wren 72-MB drive, the heads need move only after reading a 76-kB cylinder spread across nine magnetic surfaces on five platters (the tenth surface is reserved for head positioning information). Thus the heads move only one-eighth as often as with a floppy disk. (Nevertheless, that's still a far cry from an Atlas minicomputer drive, which has 1-MB cylinders.)

Will all the information for a particular file fit in a single cylinder? The disk operating system manages the drive by dividing it into a minimum size unit called a cluster, which is usually smaller than a cylinder. The oper-

by Cary Lu

ating system allocates as many clusters as necessary to store any given file. A large cluster size permits quicker disk access by reducing head seeks. But since a cluster is also usually the minimum size for a file, large clusters use space inefficiently, particularly if you store many files that are smaller than a cluster. In a few systems, users can select cluster size; more often the size is fixed.

When you put files on a new hard disk, the operating system places each one in contiguous clusters, so the file can be read with minimal head seeks. But during use, when you erase and create files, this neat disk organization comes apart; files, particularly large files, can become scattered over the entire disk. The drive slows down, since the heads must perform more and longer seeks to read the files.

SoftLogic's Disk Optimizer fixes file fragmentation by rebuilding hard disk files, placing them back in contiguous clusters. The performance improvement depends on the circumstances; for instance, a 510-record dBase II file that took 110 seconds to index when fragmented into 21 noncontiguous clusters took 80 seconds after consolidation by Disk Optimizer.

Once the head is on a desired track, how fast can it supply data to the computer? Hard disks typically spin at 3600 rpm, with a raw data rate of 625 kB per second. The IBM PC and PC/AT only accept information at 350 kB per second or slower, so the disk controller slows the transfer rate by skipping sectors during operation and picking them up on subsequent revolutions. The number of revolutions required to read or write an entire track is called the interleave factor; random-access memory in the disk controller circuit serves as a buffer for the process. All else being equal, the smaller the interleave factor, the faster the disk drive; however, overall performance depends on the interaction of access time, cylinder size, interleave factor, transfer rate, and controlling software.

Aside from size and performance, there are other hard disk features to look for. The most fragile part of a drive is the magnetic surfaces; when the head lands on the surface during power-down, the surface wears a little (during operation, the heads fly over the surface without touching it). Hard disk drives have a landing area set aside for the heads that is not used for storing information. The better hard disk designs automatically move the heads to the landing zone when the power goes off. If a drive lacks this feature, you must take care to park the heads when moving the computer.

Standard MS-DOS limits the maximum storage capacity of a hard disk drive to 32 MB. Larger hard disks must be divided into several logical drives, which behave as if they were physically separate. Thus a 72-MB drive could be divided into C: and D: drives with 32 MB each and an E: drive with 8 MB. This partitioning does not usually create a problem unless you work with extremely large files. Dividing the disk into several logical drives often eases disk organization, particularly when software does not recognize subdirectories; you can keep the program files on C: and the data files on D:.

In some situations—particularly with very large data files—you may not want to break a large disk drive into several logical drives, and may even want to combine two physical drives into a single logical drive. Emerald Systems and other companies supply such software. Breaking the 32-MB MS-DOS limit is usually done by increasing the cluster size, with the minor disadvantages previously described.

Hard disks have generally been connected to IBM PCs via a separate disk controller plugged into the computer's bus. A second connection strategy is emerging based on the Small Computer Systems Interface (SCSI). In this configuration, you connect an SCSI interface card to the computer, and a total of eight SCSI devices (including the computer) can communicate with each other. Each attached device contains its own SCSI controller; devices include not only hard disk drives but also optical discs, scanners, controllers, and other equipment that can take advantage of a relatively fast input/output channel to the computer. The Macintosh Plus also uses SCSI disk drives, so the same physical drive can be attached to a Macintosh or IBM PC; because of formatting differences, however, they cannot read files prepared on the other machine. The increased flexibility that SCSI drives will provide will be worth the extra $50–$100.

Companies

Alpha Data (Atlas disk drive), 20750 Marilla St., Chatsworth, CA 91311, (818) 882–6500
Emerald Systems, 4757 Morena Blvd., San Diego, CA 92117, (619) 270–1994
IDEAssociates, 29 Dunham Rd., Billerica, MA 01821, (617) 663–6878
Plus Development, 1778 McCarthy Blvd., Milpitas, CA 95035, (408) 946–3700
SoftLogic Solutions, 530 Chestnut St., Manchester, NH 03101, (603) 627–9900

Where should you buy a hard disk drive? The identical hard disk drive can sell for a wide range of prices; for instance, a 72-MB Control Data Wren drive can be priced at as little as $1500 or as much as $5000. To install one yourself, you must decide whether you have the modest mechanical skills necessary and, more important, whether you can cope with the technical problems that frequently crop up. Mail-order stores boast the lowest prices, but go this route only if you have expertise or friends who can help out. Otherwise you may find it safer to pay more to a dealer who will install the drive and make sure that it works. Some companies such as IDEAssociates charge a premium price but offer trade-up policies and longer guarantees.

The easiest hard disks to install are the ones mounted on an expansion card, particularly the small, elegant Hardcard from Plus Development. The disks-on-a-card are generally low-performance designs because of space restrictions, and compatibility is still a problem on some IBM PC clones.

In the next few years, improvements in hard disk drives will come mainly in the areas of improved transfer rates and higher capacity. New microcomputers will accept information as fast as a disk drive can supply it. Increased storage is possible through the simple expedients of increasing the number of platters, the number of cylinders, and the recording density. With perpendicular recording, the tiny magnetic domains that store information are turned on their sides, allowing bits to be packed five times closer together. (So far, though, problems with manufacturing media have blocked production.) Half-height drives and micro-Winchesters will start boasting medium- and then high-performance specifications.

The first commercial hard disk drives for microcomputers stored only 5 MB. When these $3000 disk drives appeared in 1981, we all thought 5 MB was huge. When will we think a gigabyte optical disc isn't enough? □

Cary Lu in microcomputer editor of HIGH TECHNOLOGY.

TAKING THE WIND OUT OF WIND SHEAR

Early detection and guidance systems will make flying safer

While making its final approach to land at Dallas–Fort Worth Airport on Aug. 2, 1985, Delta Flight 191 was told to reduce its speed to 160 knots, well above the plane's stalling speed of 112 knots. It was a routine request, and the pilot complied. But soon a sharp burst in speed—about 40 knots—appeared on the L-1011's airspeed indicator. Unaware of what had caused the increase, the pilot reduced power to maintain 160 knots. Within seconds, the most treacherous characteristic of wind shear was manifested: What had been a 40-knot headwind became a 40-knot tailwind. As the jet's airspeed dropped by 80 knots to well below stalling speed, the pilot responded by setting full power with the throttles. But it was too late—the big engines required several seconds to develop maximum thrust. Recovery and sustained flight were impossible at the plane's low altitude, and the resulting crash killed 136 of the 167 people aboard.

Can such disasters be averted? At least three companies are working on systems that warn pilots of impending wind shears and help them to fly through them.

The need for such systems is obvious. According to records of the National Transportation Safety Board, wind shear has caused at least four airline accidents in the U.S. over the past 10 years, with 401 fatalities. Wind shears have torn apart small aircraft, scattering their wreckage across several square miles. And a number of other incidents with large and small aircraft have involved wind shear as a contributing factor.

by Jeff Richmond

A wind shear is any change in wind speed or direction that occurs over such a short distance or in such a brief period of time that the velocity of air moving across the wings of an aircraft is rapidly changed. The sudden replacement of a strong headwind by a tailwind, for example, can cause a significant reduction in lift, which can then result in aerodynamic stall.

The most threatening types of wind shears are downbursts, or microbursts—descending shafts of air that are usually associated with the active cumulonimbus clouds typical of building thunderstorms. Microbursts are created when cloud-forming water droplets, having been lifted by strong updrafts, become too heavy and begin to rush down like a runaway elevator. A microburst less than half a mile wide can pack the force of a tornado.

Weather radars aboard aircraft allow pilots to fly around these violent air masses while cruising at high altitude, but this flexibility vanishes during takeoff and landing. Nevertheless, two approaches exist for combating the threat of a microburst. One is an improved ground-based system that enables air-traffic controllers to detect microbursts, locate them precisely, and warn aircraft away from them. The alternative is a system on individual aircraft that alerts the crew to the onset of a microburst and provides direct guidance via the flight instruments showing how to fly through it.

The Federal Aviation Administration (FAA) currently uses a Low Level Wind Shear Alert System (LLWSAS), which consists of sensors for wind speed and direction located at various points around airports. Each sensor transmits data to a central processor that compares inputs with those from an indicator in the center of the field. This ground-based system is effective in the immediate vicinity of the airport, but it doesn't monitor the approach and departure paths beyond airport boundaries—the regions where planes are most vulnerable to wind shears. And it is a reporting system rather than a predictive one: Up to two minutes may pass between the onset of a significant downburst and the controller's report on it. Even then, pilots must interpret the data and judge whether to continue along their planned flight paths. In fact, an LLWSAS was operating at Dallas–Fort Worth when Delta 191 crashed.

The FAA is now developing more advanced ground-based systems. But airborne wind shear warning systems offer a more immediate means of avoiding disaster. They consist of accelerometers that detect any uncommanded movement of the aircraft from the anticipated flight path and any unexpected change in speed.

Sperry's airborne program flashes a warning when it detects a wind reversal typical of a wind shear.

While such systems protect only the aircraft in which they are installed, they give pilots critical data and immediate guidance. Crews need more than a simple warning indicator, because flying through a microburst requires aircraft-maneuvering skill that is beyond the experience and training of most pilots.

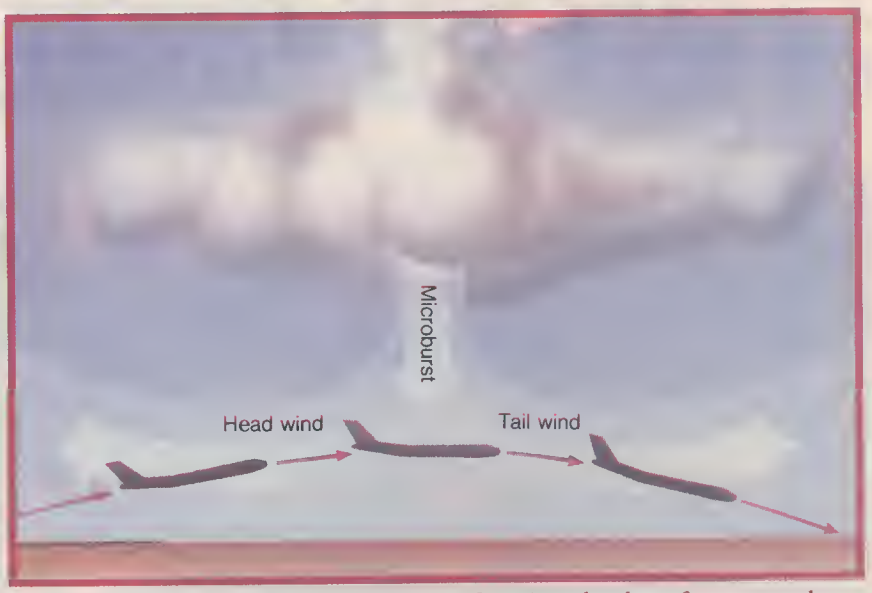
Under normal flying conditions, the flow of air across the wings can be visualized as parallel to the surface over which the plane is flying. Thus the angle of attack—between the wing and the flow of air—is roughly the same as the angle

between the wing and the surface. In a microburst, however, the flow of air has a downward component that immediately reduces the angle of attack. To fly through the burst, the pilot must raise the nose of the aircraft to what seems higher than the normal pitch angle and apply maximum power.

Several companies, including Boeing Aircraft (Seattle), Safe Flight Instrument (White Plains, N.Y.), and Sperry (Phoenix), have developed sensors to alert crews to the onset of a downburst and guide them through it. Safe Flight's Wind Shear Warning/Recovery Guidance (WSW/RG) system uses a computer with internal longitudinal and vertical accelerometers to calculate the aircraft's performance with reference to the surface. The computer also receives inputs from the airspeed and angle-of-attack sensors that monitor the flight relative to the surrounding air. If the WSW/RG system detects a sudden increase in airspeed without a corresponding increase in ground speed, the only possible cause is a rapid increase in the velocity of the headwind—a wind shear. The system sounds an alarm before dangerous trends have time to develop, and displays pitch commands on the pilot's instrument panel indicating the precise attitude control to fly through the microburst.

Given the speed with which wind shears cause disaster, the pilot must start recovery maneuvers as soon as the warning sounds. Thus it is essential to avoid false alarms. To achieve that, Safe Flight flew its system deactivated for two years in a United Airlines Boeing 727 to gather data on air turbulence. Measurements showed that turbulence in normal flight rarely exerted more than 0.12 g of force on airliners. Since pilots can cope with forces slightly stronger than that, Safe Flight calibrated its system to sound the alarm at 0.15 g. The system has been thoroughly tested and accepted by the FAA, and is currently installed on more than 40 corporate jets. Using aircraft simulators, Eastern, United, and Boeing have conducted additional tests, which show that the system reacts accurately to wind shears.

The FAA certified Sperry's Wind Shear Detection and Alert program last November, following computer modeling and in-flight testing on Piedmont Airlines flights. The computer program, which Piedmont is installing on its Boeing 737-200s, enhances Sperry's Performance Management System—a pilot aid designed to save fuel and maintenance costs. Using an algorithm based on pitch angle, angle of attack, real airspeed, and vertical and longitudinal acceleration, the program illuminates an amber light when it detects a downdraft or microburst likely to become a wind shear. When it senses further evidence of wind shear, such as a reversal of wind direction, it flashes a "wind shear alert" and lights a red lamp. Sperry is developing an upgraded system that will give flying guidance; it expects certification by the end of the year.



The worst wind shear is a microburst, created when air rushes down from a cumulonimbus cloud and radiates outward near ground level. The sudden change in wind direction can cause even large airliners to stall.

Boeing's system provides a warning and partial guidance for flying through wind shears; alerts show up on the instruments when the plane is approaching a dangerous pitch attitude. The company expects the system to be certified for 737s in June, and plans to develop versions for its 757s and 767s.

Presumably, the crash of Delta 191 could have been avoided had it been equipped with an on-board wind shear and recovery guidance system. As the aircraft entered the initial stages of the microburst, sensors would have detected a rapid increase in airspeed without an increase in actual speed over the ground, indicating a strong gust of headwind rather than the acceleration of the aircraft that the pilot assumed. The system would have immediately alerted the pilot to the wind shear. Instead of throttling back to the target speed of 160 knots, the crew would have applied full power, established and held the maximum angle of attack, scrubbed the landing, and gone around for another try.

Leonard Green, president of Safe Flight, argues that the FAA should require wind shear warning and guidance devices on all airline-operated aircraft. In fact, because the devices have emerged so recently, the FAA has just started certifying them and airlines cannot install them without FAA approval. "It's ironic," says Green, "that six IBM executives died in the Dallas crash of an unprotected airliner, when the IBM Corporate Aircraft Fleet had airborne wind shear protection." □

Jeff Richmond is a freelance writer specializing in aerospace topics. He lives in Danbury, Conn.

MARK E. ALSOP

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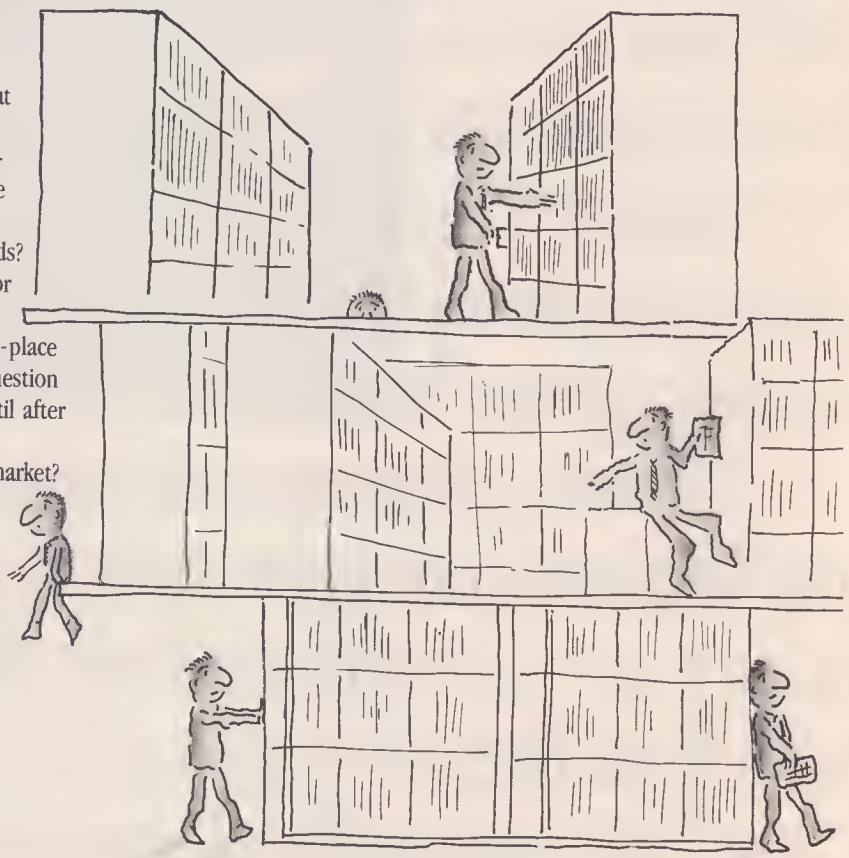

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PERSPECTIVES

Micros get animated

Drawing animated cartoons, a slow and time-consuming art, has until recently been overlooked by the revolution in personal computer graphics. But now cartoonists have some computer-aided animation tools with real-time capabilities: The Animation Studio, developed for the IBM PC by Lecht Sciences (New York), and VideoWorks, published by Hayden Software (Lowell, Mass.) for the Apple Macintosh.

The Animation Studio grew out of The Graphics Machine, an "engine" for animation that Lecht Sciences' programmers created to develop a computer-graphics show for the Nippon Telegraph & Telephone pavilion at Japan's science and technology fair, Tsukuba Expo '85. The new program is intended for creating full-motion cartoons, movies, presentation graphics, television commercials, business presentations, and computer-aided instruction. Equipped with at least 256 kilobytes of memory, a graphics adapter board, and a pointing device such as a mouse or a joystick, the program can produce flicker-free movies at a sustained rate of 18 frames per second. It holds up to 5000 frames simultaneously in memory—enough for a five-minute film—and additional memory can extend this length.

Hayden's VideoWorks is similar in many respects, but there are two major drawbacks: The progran is limited to presenting just 24 objects per frame, and the Macintosh monitor displays only gray monochrome. Marc Cantor, president of Macroworld (Chicago) and the creator of VideoWorks, points out that while The Animation Studio is aimed at the professional animator, "the VideoWorks program is for children and others who wouldn't otherwise be able to do animation."

Written in assembly language for efficiency, The Animation Studio simulates the animator's tools, including the animation camera stand and cels (transparent rectangles containing painted images that can be moved, zoomed back and forth, enlarged, reduced, or placed in three-dimensional perspective). The program offers the professional "squash and stretch" and "in-betweening" features considered by Walt Disney Studios and others to be fundamental effects. The first feature creates the change of shape that seems to occur when a ball bounces or a person runs. The ball seems to compress briefly when it hits the floor, and the person's body appears to grow longer, shorter, or wider as he runs, jumps, and stops. The second feature allows the computer to fill in motions between frames and smooth the action.

This type of PC-based animation software doesn't have to be limited to cartoons: Software developers could use it to create simulations for anything from scientific applications to videogames. An expert system animation might explain a process or show how to repair or assemble a piece of equipment. And advertising art directors might use animation software to replace expensive storyboarding with rough films.

Sequence of swimming fish from film created by The Animation Studio shows start (top) and end (center) entered into the system. Intervening frames (such as at bottom) are generated automatically.

If a picture is worth a thousand words, inexpensive animated pictures might be worth many thousands. □

—Jack B. Rochester

Etching chips with lasers

A new way of fabricating integrated circuits (ICs) requires less equipment, fewer steps, and less stringent quality control measures than the complex method used by semiconductor houses to make ICs today. It may even allow computer and electronic-equipment companies to start making their products' crucial ICs themselves.

In the new technique, a laser "draws" micron-size transistors and their interconnections on a silicon wafer by scanning the surface in the presence of certain gases. Under ordinary conditions, these gases have no effect on the wafer. The energy of a focused laser beam, however, decomposes the gases into compounds that define circuit elements and their interconnections, either by etching away unwanted material or by deposition onto the substrate.

Conventional IC fabrication relies on photolithography, a time-consuming process that uses equipment costing as much as $100 million. The circuit's layout must first be painstakingly converted to a set of up to a dozen patterned photomasks. These masks are carefully positioned over the wafer during a sequence of thermal and photochemical procedures, including the deposition of photoresistive films, baking, exposure to light, etching, and introduction of dopants (impurities). As many as 100 steps are needed, each of which increases the risk of flaws that will yield faulty chips. It's not unusual for half the chips on a wafer not to work after days or even weeks of setup.

Lasers are not new in IC production; indeed, sales of laser systems for semiconductor processing are expected to reach $3.5 billion by the end of the decade, according to *Electronics* magazine. Currently, lasers are being used mainly for ancillary tasks such as setting the value of a circuit's resistors by trimming them to the correct length, or aligning lithographic masks. But

HAL DRELLICH

laser systems that play the leading, rather than supporting, role in chip making should account for $250 million of the 1990 total, according to a market study by Burns Research (Santa Clara, Cal.).

So far, the technology has remained mostly within the province of university and government R&D. Some of the biggest advances, for example, have come from Lawrence Livermore National Laboratory (Livermore, Cal.), where researchers have used lasers to make transistors with dimensions and performance comparable to today's commercial chips, and to wire the transistors together into basic logic elements.

The transistors' source and drain regions (where current enters and exits) are created by doping the silicon with phosphorus, which the laser produces by breaking up molecules of phosphine gas (PH_3). Hydrogen chloride gas serves as an etchant when activated by the beam's heat. Connecting the transistors to each other are lines of conductive material thinner than 1 micron. The laser deposits polycrystalline silicon, for example, by decomposing the gas silane (SiH_4) along with phosphine; tungsten is generated by laser illumination of tungsten hexafluoride (WF_6), and nickel from nickel carbonyl ($Ni(CO)_4$).

The Livermore experiments show that the laser process not only works well but works quickly. The beams are able to "write" polysilicon lines at 1 centimeter per second, and metal lines up to 10 times faster. At these rates, a laser could produce 1000 transistors per second—the main goal of the Navy and Energy Department's current S-1 supercomputer project, of which the Livermore effort is a part. It would thus be possible to fabricate a different supercomputer chip each day, with each chip crammed with 100 million transistors.

The first and only company to market laser systems for writing chips is XMR (Santa Clara, Cal.). XMR recently came out with a $200,000 micromachining center, which uses an ultraviolet laser to etch patterns and to shave off layers as thin as 0.1 micron. This spring, XMR plans to introduce a more versatile, $450,000 system that can dope a wafer to create the junctions that are the heart of all transistors.

The first commercial market for the process will likely be the fabrication of custom chips by companies that make computers and other electronic systems; the lasers could turn a design into a prototype in one day, in contrast to the several days or weeks needed with photolithography. The laser technique might also be used to repair ICs that were originally processed by conventional photolithography, and eventually to fabricate wafer-scale ICs—circuits that occupy an entire wafer rather than a small section of one (i.e., a chip) as is standard now. A single wafer-scale IC might be as powerful as a mainframe computer. □ ***—John Javetsky***

Recording music on floppy disks

CompuSonics, a sound-studio equipment maker, is planning to introduce this year the first digital home recording computer that uses floppy disks. Employing three 32-bit microprocessors, the DSP-1000 recorder converts audio signals into abbreviated digital data, encoding the equivalent of a standard LP phonograph record on a 5¼-inch floppy disk.

Tape-based digital recorders are being developed by Japanese manufacturers; Onkyo (Tokyo), for example, has already demonstrated a preproduction prototype. But CompuSonics founder and president David Schwartz claims that the random-access capability of the DSP-1000 will be a big advantage over digital tape recorders, which play back sequentially. Although its projected price of about $1500 will initially restrict the DSP-1000's market to devoted audiophiles, the Denver-based company expects to sell 11,000 units its first year, increasing to more than 100,000 annually by its third year as consumer demand for the new technology rises. CompuSonics has already introduced a commercial-broadcasting version, the DSP-1500, which retails for about $2300.

Ordinarily, the data requirements for digital sound encoding are so great that less than 10 seconds of music could be stored on a standard floppy disk. But CompuSonics claims that a proprietary subsystem of the DSP-1000 and DSP-1500, called CSX, reduces data by as much as eight times, by consolidating repetitive parts and eliminating portions of the sound signal that are not discernible by the human ear. The system also employs high-performance diskettes punched from sheets of metal video-recording tape; their extremely smooth surface permits special formatting that yields 640 recording tracks, compared with fewer than 100 tracks on a conventional floppy disk.

The CSX process starts by breaking up the audible spectrum of the complete sound data (stored in the DSP-1000's buffer memory) into as many as

In this plot of music encoded by CompuSonics' CSX technique, ridges show the loudness of different frequencies. Spaces between ridges show time between changes.

128 equally spaced frequency bands. Every tenth of a second, each frequency band is examined for changes in amplitude. If there are no changes—meaning there is a continuous tone within the band—the continuation is not recorded; instead, a digital clock notation tells the recorder how long to continue the tone during playback.

Further compression is achieved by breaking the continuity of the audio waves and creating the equivalent of motion-picture frames, on the theory that the ear cannot distinguish such brief interruptions any more than the eye perceives the breaks between the 24 frames per second of a motion picture. These audio "frames" are spaced a hundredth of a second apart. The perceived sound during playback is indistinguishable from that of a continuous recording played from a compact disc, says Schwartz, even though the information actually recorded is reduced significantly.

CompuSonics notes that both commercial and home models can interface with microcomputers, opening up new possibilities. For example, the company is preparing software that enables users to digitally edit recordings and duplicate old records and tapes without the annoying sound distortion caused by wear. With special programming to allow a personal computer to encode a recording with additional sound data, home recorders could even imitate the synthetic sound reconstruction used in professional studios for augmenting the tonal range and dynamics of early records. And computerized disc recorders could double as audio synthesizers, creating new sounds or mixing synthesized material with prerecorded live sound.

But Schwartz says the greatest asset of CSX may be its eventual ability to telerecord via a phone link. "CSX makes the data small enough to fit down a wire," he says, and DSP recorders have a built-in digital audio transceiver interface that will accept high-speed modems such as the Flex Tie from California Microwave (Sunnyvale, Cal.). Because this feature makes the recorders compatible with AT&T's Accunet digital communication network, Schwartz says it may someday allow recorded music to be sold like cable television, piped into the user's home for a fee: "You would simply call up and make a purchase from a record store that's really a computer." □

—Arthur J. Zuckerman

RESOURCES

Information sources for topics covered in our feature articles

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Contacts

National Telecommunications and Information Admin., U.S. Dept. of Commerce, 14th St. & Constitution Ave., NW, Wash., DC 20230, (202) 377–1551.

North American Telecommunications Assn. (NATA), 2000 M St., NW, Suite 550, Wash., DC, 20036, (202) 296–9800. Publishes *1986 Telecommunications Sourcebook* ($75).

Federal Communications Commission (FCC), Office of Public Affairs, 1919 M St., NW, Rm. 202, Wash., DC 20054, (202) 254–7674.

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TECHSTARTS

WaferScale Integration: CUSTOMIZING MICROPROCESSORS

Semicustom microchips made by patching together predesigned, rudimentary circuit blocks (known as "standard cell" designs) started out as fairly simple devices that could perform just a few functions. Today, WaferScale Integration (WSI) designs chips that can include an entire 32-bit microprocessor, enough memory to hold control instructions, and additional special-purpose logic circuits. With a circuit library that emphasizes high-speed, complex logic blocks, WSI's market includes applications such as engineering workstations, graphics processors, and digital signal processors. It has also licensed its technology to a chip manufacturing joint venture between RCA and Japan's Sharp. Competitors in the semicustom chip market include LSI Logic and VLSI Technology.

Eli Harari of WaferScale Integration, shown with the company's computer-based tools for chip design.

Financing: $23 million in venture capital from investors including manufacturers RCA, Sharp, Intergraph, and Tadiran, and venture capital firms Adler & Co., J. H. Whitney, Robertson Colman & Stephens, Oak Investment Partners, Accel Capital Partners, and Warburg Pincus Capital.

Management: Founders Eli Harari (president), Stephen Su (VP of technology), and Terry Leeder (VP of application-specific integrated circuits) worked together at semiconductor firm Synertek, where Harari was VP of operations and technology, Su was director of advanced technology, and Leeder was a product line business director. Previously Harari was manager of technology development for Intel.

Location: 47280 Kato Rd., Fremont, CA 94538, (415) 656–5400.

Founded: August 1983.

Trellis Communications: WIRING BUILDINGS WITH FIBER OPTIC NETWORKS

By far the largest market for fiber optics today is in long-distance communication via telephone, but applications that involve sending computer data and audio or video signals over short distances are growing rapidly. Trellis intends to design building- and campus-wide networks that use a combination of fiber optic and copper cable to carry all of an organization's data, voice, and video traffic. The company's target customers include large companies and commercial real estate firms developing both single- and multiple-tenant buildings. Trellis sees this as its own niche: Although many companies in the fiber optics industry make systems to link certain types of devices, none provide networks that support a wide range of equipment.

Financing: Seed capital provided by the founders.

Management: Richard A. Cerny, president and founder, was chairman, CEO, and a founder of Artel Communications, a maker of fiber optic systems for video, audio, and computer graphics transmissions. Previously he cofounded and was director of marketing for Valtec's Communication Fiberoptics division. Allen B. Kasiewicz, VP and cofounder, was director of operations for Phalo Optical Systems, a maker of fiber optic cable and components. Previously, he was director of marketing for General Cable.

Location: 18 Pelham Rd., Salem, NH 03079, (603) 898–3434.

Founded: December 1985.

IVS: IMPROVING THE VIEW THROUGH A MICROSCOPE

Digital analysis can enhance images that range from photos of the rings around Uranus to magnified views of cells within a living organism. IVS, which concentrates on image processing at the minute end of the scale, makes digital microscopes that can examine objects with dimensions of less than a micron. Its first integrated system, introduced in 1984, is aimed at biological researchers in fields such as molecular biology and immunology. A new version, aimed at the semiconductor industry, can assist both the production and inspection processes. Competitors include makers of optical microscopes such as Leitz and Zeiss, as well as firms using newer technologies like laser microscope maker SiScan.

Financing: $1.5 million from investors including Charles River Partnership, First Capital of Chicago, and Turner Revis Associates.

Management: Founders Thorleif Knutrud, Eutimio A. Saporetti, and Don Yansen worked together as consultants for MIT/Lincoln Labs in a project to develop the first video analyzer. Knutrud is VP of manufacturing, Saporetti is VP of engineering, and Yansen is VP of technology. Richard Koerner, president and CEO, was cofounder and general manager of NEC Electronics, a semiconductor firm.

Location: 45 Winthrop St., Concord, MA 01742, (617) 371–2600.

Founded: May 1980.

ADVANCED COMPOSITES SHOW STEADY GROWTH

Market expands as aerospace firms shift over to lighter materials

Advanced polymer composites—generally consisting of carbon, aramid (a plastic fiber), and glass fibers embedded in plastic resins—are gaining in importance among high-performance materials. Composite-based products are significantly lighter and stronger than those made from traditional alloys, and they are corrosion-free. They can also be molded into structures made of fewer parts, reducing assembly and maintenance costs. Worldwide sales of advanced composites are expected to grow almost 15% annually for the remainder of the century—from $1.4 billion in 1985 to around $12 billion by the year 2000, according to market research firm Strategic Analysis (Reading, Pa.).

Aerospace companies such as McDonnell Douglas, Grumman, and Northrop make up 60% of the market for composites. This is also the fastest-growing segment (22% a year), paced by an anticipated increase in the use of composites in military aircraft from 5% of total structural weight today to at least 40% within the next ten years. New markets for composite structures are also opening in the manufacture of helicopters and civilian aircraft. Beech, for example, is developing an all-composite business airplane known as the Starship, while Boeing uses composites in its latest generation of jet aircraft as well as in retrofitting older planes.

Sporting goods such as golf clubs, tennis rackets, and bicycle wheels represent 20% of the market, but this is a mature sector characterized by slow growth rates of about 3% annually. The automotive and industrial sector, with 15% of the market, is an area of potential growth. But although composites are used in drive shafts for Ford vans, leaf springs for General Motors cars, and some industrial machinery, further applications are currently hindered by the high costs of carbon fiber (over $10 per pound) and by composite fabrication processes not yet well-adapted to assembly-line operations.

by Tyler H. Leinbach

Graphite fiber produced by Hercules is used in a wing of the McDonnell Douglas AV8-B Harrier, shown under constuction.

Major players in the industry include several large, diversified companies such as Ciba-Geigy, Imperial Chemical Industries, BASF, DuPont, and Amoco. Three firms that receive a substantial portion of their revenues from composite sales, and that are well-positioned to take advantage of growing aerospace markets, are Hercules (Wilmington, Del.), Hexcel (San Francisco), and Lunn Industries (Wyandanch, N.Y.).

Hercules (NYSE: HPC) is the world's largest supplier of high-strength carbon-fiber and carbon-composite structures, selling to the aerospace, automotive, oil drilling, and marine industries. Its composite operations are completely integrated, from the manufacture of raw materials such as resins and fibers to finished structures such as rocket cases and aircraft parts. Hercules is currently involved in a number of government programs, including the Air Force's Advanced Tactical Fighter, which may be 60% composites by weight. The company is also developing a solid-rocket booster case that will be flight-tested by NASA as a possible replacement for the steel case used by Morton-Thiokol on the Space Shuttle. This test program was decided upon before the ill-fated Challenger flight in January.

In 1984, Hercules made profits of $197 million based on sales of $2.57 billion, for earnings per share of $3.54. Last year, sales inched up to $2.59 billion, while net income dropped to $133 million and earnings per share to $2.40. This decrease was due to the disposal and subsequent write-off of several marginally profitable businesses outside the composite arena.

Hexcel (NYSE: HXL) supplies composite materials and honeycomb (hexagonally cross-sectioned) structures to civilian and military aircraft markets. The company's products include engine enclosures and radar housings for such military aircraft as the B1-B bomber, the C5-B cargo transport, and the AV8-B vertical-takeoff fighter. Hexcel has diversified into nonmilitary markets by using composites in the production of synthetic cast materials for orthopedic applications. The company is planning to move into a related market by developing artificial tendons and ligaments for holding human joints in place.

In 1984, Hexcel reported sales of $181 million, profits of $5.9 million, and $1.68 earnings per share; these figures rose in 1985 to $235 million in sales, $7.7 million in profits, and $1.89 earnings per share.

Lunn Industries (OTC: LUNN) is a small company that pioneered the application of low-performance composites for use in fiberglass automobile bodies. But over the past few years, the firm has turned almost entirely to advanced composites for more lucrative niches in the marine electronics and aerospace markets. Its products now include composite-based antennas, mast fairings, and radar domes for Trident submarines, as well as components for surface-to-air missiles, military aircraft, and flight simulators.

Lunn estimates that in 1985, sales were $6.3 million and profits $438,000, yielding 23¢ earnings per share, an improvement over the previous year's figures of $5.8 million in sales, $235,000 in profits, and earnings per share of 16¢. □

Tyler H. Leinbach is a consultant with Strategic Analysis, a market research firm based in Reading, Pa.

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